GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION
SPONSORED PROJECT INITIATION

Date: 5 September 1979

Project Title: Development of a Coal Burning Pulsating Combustor for Power Generation

Project No: E-16-646

Project Director: Dr. B. T. Zinn

Sponsor: Department of Energy; Oak Ridge Operations

Agreement Period: From 1 June 1979 Until ~~31 May 1980~~ Sept 30, 1980

Type Agreement: Contract No. DE-AS05-79ER10068

Amount: $68,693 DOE
4,748 GIT (E-16-337)
$73,441 TOTAL

Reports Required: Contract Management Summary Report; Technical Progress Report; Final Technical Report.

Sponsor Contact Person (s):

Technical Matters	Contractual Matters (thru OCA)
	A. H. Frost, Jr., Chief Contract Management Branch Procurement and Contracts Division Department of Energy Oak Ridge Operations P.O. Drawer E Oak Ridge, Tennessee 37830 Phone: 615/576-0791

Defense Priority Rating: None

Assigned to: Aerospace Engineering (School/Laboratory)

COPIES TO:

- Project Director
- Division Chief (EES)
- School/Laboratory Director
- Dean/Director—EES
- Accounting Office
- Procurement Office
- Security Coordinator (OCA)
- Reports Coordinator (OCA)
- Library, Technical Reports Section
- EES Information Office
- EES Reports & Procedures
- Project File (OCA)
- Project Code (GTRI)
- Other C. E. Smith

CA—3 (3/76)

GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT TERMINATION

Date: 8/24/81

Project Title: Development of a Coal Burning Pulsating Combustor for Power Generation

Project No: E-16-646

Project Director: Dr. B. T. Zinn

Sponsor: Department of Energy; Oak Ridge Operations

Effective Termination Date: 9/30/80

Clearance of Accounting Charges: 9/30/80

Grant/Contract Closeout Actions Remaining:
none

_ Final Invoice and Closing Documents
_ Final Fiscal Report
_ Final Report of Inventions
_ Govt. Property Inventory & Related Certificate
_ Classified Material Certificate
_ Other _____

Continued by E-16-604

Assigned to: Aerospace Engineering (School/Laboratory)

COPIES TO:

Project Director
Division Chief (EES)
School/Laboratory Director
Dean/Director–EES
Accounting Office
Procurement Office
Security Coordinator (OCA)
Reports Coordinator (OCA)
Library, Technical Reports Section
EES Information Office
Project File (OCA)
Project Code (GTRI)
Other _____

CA-4 (1/79)

E-16-646

GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332

SCHOOL OF
AEROSPACE ENGINEERING

404-894-3000

DANIEL GUGGENHEIM SCHOOL
OF AERONAUTICS

October 5, 1979

Dr. Ernest Blase
Department of Energy
Washington, D.C. 20585

Subject: Progress Report for Period June 1, 1979 through September 30, 1979 for Work Conducted Under DOE Contract Number DE-AS05-79ER10068

This, first, progress report covers a four-month period as the approval of the contract by DOE occurred in September while the initiation date of this contract dates back to June 1, 1979. A limited amount of work has been conducted, however, during the June-August period in anticipation of DOE approval of this contract.

Initial efforts under this contract involved a broad review of existing literature on pulsating combustion. The works of Carrier and Bailey (i.e., Carrier, G.F., The mechanics of the Rijke Tube, Quart. of Applied Math., Vol. XII, No. 4, Jan. 1955 and Bailey, J. J., A Type of Flame-Excited Oscillation in a Tube, Journal of Applied Mechanics, September 1957), received special attention as the theoretical approaches used therein are likely to be useful in the design and analysis of the proposed coal burning pulsating combustor. A broad review of the literature on fluidized bed coal combustion was also made for comparison purposes.

The design of hardware for TASK I was completed, and fabrication is now well under way. Instrumentation in preparation includes hot film anemometer, thermocouples and pressure transducer for velocity temperature and pressure measurements , respectively.

The initial set of experiments will be designed to determine the acoustic characteristics of the developed experimental setup. As a simplification, these experiments will be conducted with an electric heater rather than burning coal, as the heating source. This will allow for the clear determination of the dependence of the acoustic properties of the designed combustor upon the heating rate and location of the heat source. Subsequently, these data will be used in the interpretation and analysis of the performance of the developed combustor when burning coal is used.

Sincerely,

Ben T. Zinn
Principal Investigator

BTZ/jj

FORM ERDA 535
2/1/77)

U S ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

MILESTONE PLAN AND MANAGEMENT REPORT

PAGE

1 Contract Identification	2 Reporting Period	3 Contract Number
Development of a Coal Burning Pulsating Combustor for Power Generation	1 June 1979 through 30 Sept 1979	DE-AS05-79ER10068

Contractor (name, address) Georgia Tech Research Institute
Administration Building
Georgia Institute of Technology
Atlanta, Georgia 30332

5 Contract Start Date: 1 June 1979

6 Contract Completion Date: 31 May 1980

Identification Number	8. Reporting Category (e.g., contract line item or work breakdown structure element)	9. Fiscal Years and Months — FY 79-80: J J A S O N D J F M A M	10
1	Task I		
1.1	Design		
1.2	Fabrication		
1.3	Installation and Checkout		
1.4	Testing		
1.5	Data Analysis		
2	Task II		
2.1	Design		
2.2	Fabrication		
2.3	Installation and Checkout		
2.4	Testing		
2.5	Data Analysis		
3	FINAL REPORT PREPARATION		

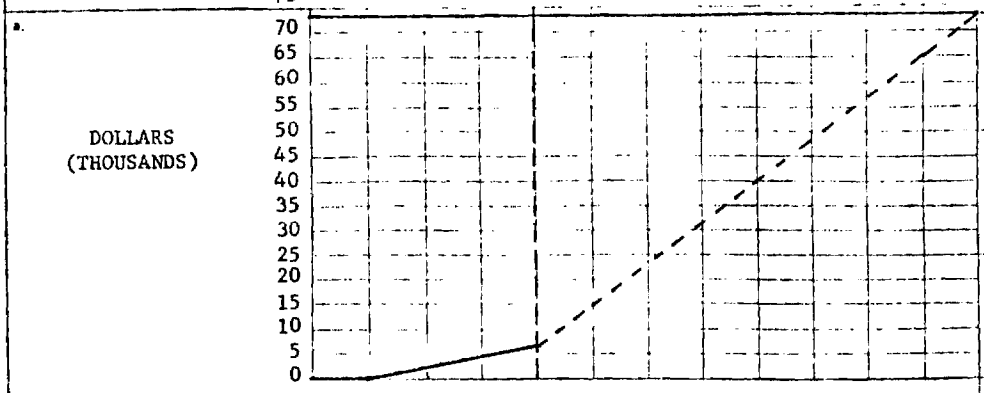
11 Remarks ◊ A two month extension has been requested, with no change in contract funding. The extension will off-set the initial two month delay in Contract Start Date notification.

Signature of Contractor's Project Manager and Date	13. Signature of Government Technical Representative and Date
Ben T. Zinn, Principal Investigator - October 5, 1979	

1 Contract Identification: Development of a Coal Burning Pulsating Combustor for Power Generation	2 Reporting Period: 1 June through 30 Sept	3 Contract Number: DE-AS05-79ER10068
4 Contractor (name and address): Georgia Tech Research Institute, Administration Building, Georgia Institute of Technology, Atlanta, Georgia 30332		5 Contract Start Date: 1 June 1979
		6 Contract Completion Date: 31 May 1980

7 Months	J	J	A	S	O	N	D	J	F	M	A	M	8 FY 79-80

9 Cost Status



Accrued Costs													
b. Planned	0	2.15	2.15	2.15	8.37	8.37	8.37	8.37	8.37	8.37	8.37	8.40	
c. Actual	0	2.15	2.15	2.15									
d. Variance	0	0	0	0									

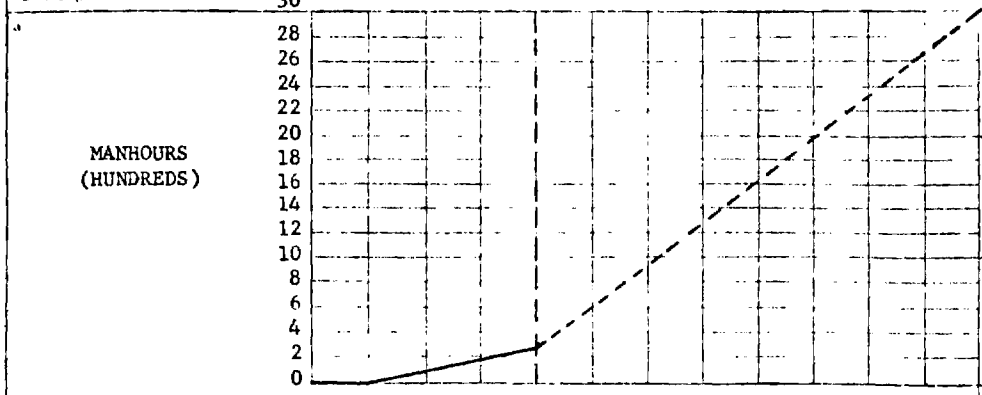
e. Actual Costs Prior FYs: 0

f. Planned Costs Prior FYs: 0

g. Total Estimated Accrued Costs for Contract: 73.44

h. Total Contract Value: 73.44

10 Manpower Status



Manpower													
b. Planned	0	0.88	0.88	0.88	3.43	3.43	3.43	3.43	3.43	3.43	3.43	3.44	
c. Actual	0	0.88	0.88	0.88									
d. Variance	0	0	0	0									

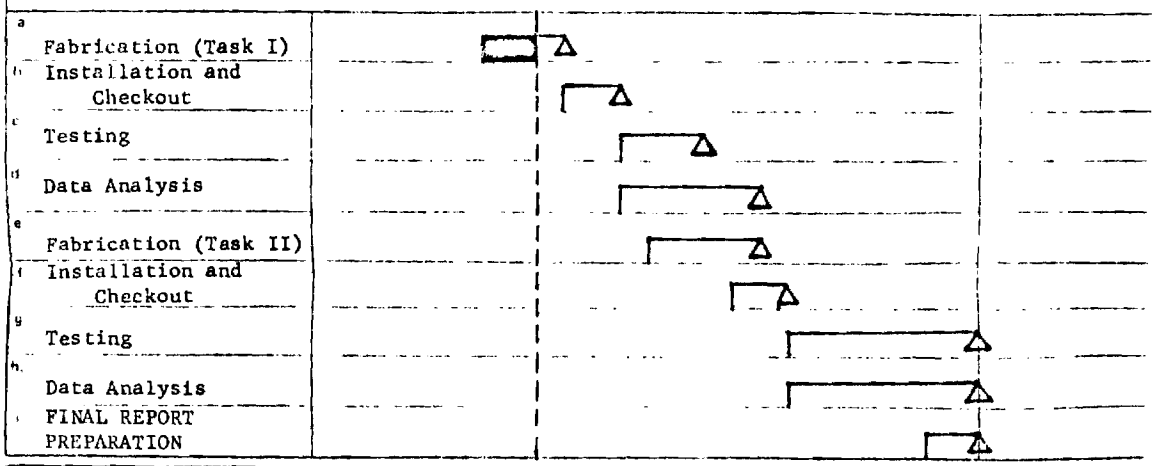
e. Actual Manpower Prior FYs: 0

f. Planned Manpower Prior FYs: 0

g. Total Estimated Manpower for Contract: 30.12

h. Total Contract Manpower: NOT SPECIFIED

11 Major Milestone Status



12 Remarks: A two month extension has been requested, with no change in contact funding. The extension will off-set the initial two month delay in contract start date notificatio

13 Signature of and Date	14 Signature of Government Technical Representative and Date
Ben T. Zinn, Principal [illegible] Oct. 5, 1979	

E-11-641

GEORGIA INSTITUTE OF TECHNOLOGY
SCHOOL OF AEROSPACE ENGINEERING
ATLANTA, GEORGIA 30332
Telephone 404-894-3033/3000
Telex: SY2507 GTRI OCA ATL

Ben T. Zinn
Regents Professor
Daniel Guggenheim
School of Aeronautics

November 5, 1979

Dr. Ernest Blase
Department of Energy
Washington D.C. 20585

Subject:

Progress Report for period Oct. 1, 1979 through Oct. 31, 1979 for work conducted under DOE Contract Number DE-AS05-79ER 10068.

Fabrication of the initial configuration of the experimental pulsating combustor apparatus has been completed. The tube has a working inside diameter of 5 1/2 inches and it consists of several sections which can be interchanged to vary the tube length from 6 to 10 feet. The variation in tube length will provide resonant frequencies from approximately 60 to 100 Hertz. The tube's support system consisting of an overhead track mechanism which will permit horizontal positioning of the tube has been fabricated and installed.

Instrumentation of the experiment is in progress. Adapters which allow radial traversing of the hot film anemometer and thermocouples have been fabricated and an infinite tube arrangement for the measurement of the dynamic pressure levels has been completed. Hook-up of the instrumentation and the check-out and calibration of the readout instruments is currently in progress.

The design criteria for the coal bed support and the coal feeding mechanism has been established and the design of these components is in progress. Work is also in progress on the design of the exhaust and filtration systems.

Analytical work during the past month was directed towards the determination of the measurements that will be required in order to obtain the acoustic driving characteristics of the mechanisms responsible for the excitation of the oscillations.

The planned experiments will be conducted in two phases with heating elements utilized as the acoustic driving source in the first phase and a coal combustion bed as the driving source in the second phase. The experimental techniques to be used in the determination of the characteristics of the acoustic driving source will be developed while the heating elements are utilized as the source of wave excitation. Once developed these techniques will be used in the determination of the acoustic driving characteristics of the burning coal bed. The acoustic driving characteristics will be determined in terms of the "Response Function" and "Admittance" of the source. These concepts provide an accurate measure of the interaction between combustion processes and acoustic fields, and have proved effective in the study of rocket motor instability.

Sincerely,

Ben T. Zinn
Principal Investigator

BTZ/jj

E16-644

GEORGIA INSTITUTE OF TECHNOLOGY
SCHOOL OF AEROSPACE ENGINEERING
ATLANTA, GEORGIA 30332
Telephone 404-894-3033/3000
Telex: SY2507 GTRI OCA ATL

Ben T. Zinn
Regents Professor
Daniel Guggenheim
School of Aeronautics

December 5, 1979

Dr. Ernest Blase
Department of Energy
Washington D.C. 20585

Subject:

Progress Report for period Nov. 1, 1979 through Nov. 30, 1979 for work conducted under DOE Contract Number DE-AS05-79ER 10068.

The design of the exhaust and filtration system for the experimental coal burning pulsating combustor has been completed and installation is now under way.

There was a slight delay in the delivery of electrical heating elements by the manufacturer and this resulted in a delay in the completion of the experimental setup installation. An effort will be made to make up for this delay. Installation of the electrical heating elements is in progress and testing should begin shortly.

A series of preliminary tests were conducted with the previously developed experimental pulsating combustor to determine the effect of pulsation on the mass burning rates of charcoal and wood. This is a Rijke tube type combustor and it consists of an iron tube with a 6 inch internal diameter and 104 inches length, mounted on a movable stand. Pulsating and steady state modes of combustion were obtained by burning the fuel bed at distances of L/4 and L/2 from the bottom of the tube, respectively. Starting with identical initial masses of fuel, the mass vs. time plots for pulsating and steady state combustion were compared. Both in the case of charcoal and wood, the mass burning rates under pulsating conditions were only slightly higher than those observed under steady state conditions. A resonant frequency of about 73 Hz. was measured under pulsating conditions. This corresponds approximately to the frequency of the first natural mode of oscillation of the tube.

Two approaches for determining the efficiency of the coal burning pulsating combustor are being studied. The first approach involves the experimental measurement of the total thermal energy output by the combustor. The ratio of this quantity to the chemical energy available in the coal will determine the efficiency of the combustor. The second approach involves the collection and characterization of the combustion products (i.e., ash, unburnt coal particles, combustion gasses, etc.) emitted by the combustor. From this, the fraction of the available chemical energy that was actually converted into thermal energy can be calculated.

An effort to theoretically model the experimental setup has been undertaken in order to provide a guide for the experimental efforts. Initially, the integral formulations of the conservation equations have been applied to a control volume surrounding the combustion bed in order to obtain relationships between the flow variables on both sides of the bed with quantities describing the behavior of the pulsating combustion bed. The resulting expressions are currently being analyzed with the aim of providing guidelines for the ensuing experimental efforts.

The Symposium on Pulse Combustion Technology for Heating Applications organized by the Argonne National Laboratory was attended and our efforts to date under this program were presented in a paper entitled "Application of Pulsating Combustion in the Burning of Solid and Coal Fuels".

Sincerely,

Ben T. Zinn
Principal Investigator

BTZ/jj

FORM ERDA 63
(2/1/77)

U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

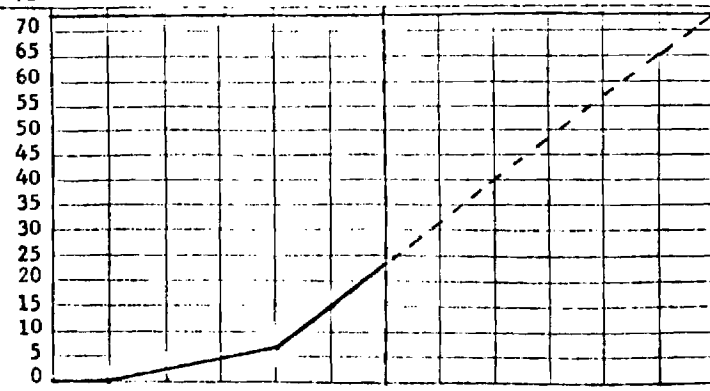
CONTRACT MANAGEMENT SUMMARY

1. Contract Identification	2. Reporting Period	3. Contract Number
Development of a Coal Burning Pulsating Combustor for Power Generation	1 Nov.-30 Nov.	DE-AS05-79ER10068

4. Contractor (name and address)	5. Contract Start Date	6. Contract Completion Date
Georgia Tech Research Institute Administration Building Georgia Institute of Technology Atlanta, Georgia 30332	1 June 1979	31 May 1980

7. Months	J	J	A	S	O	N	D	J	F	M	A	M	8. FY 79-80

9. Cost Status



Accrued Costs		J	J	A	S	O	N	D	J	F	M	A	M
	b. Planned	0	2.15	2.15	2.15	8.37	8.37	8.37	8.37	8.37	8.37	8.37	8.40
	c. Actual	0	2.15	2.15	2.15	8.37	8.37						
	d. Variance	0	0	0	0	0	0						

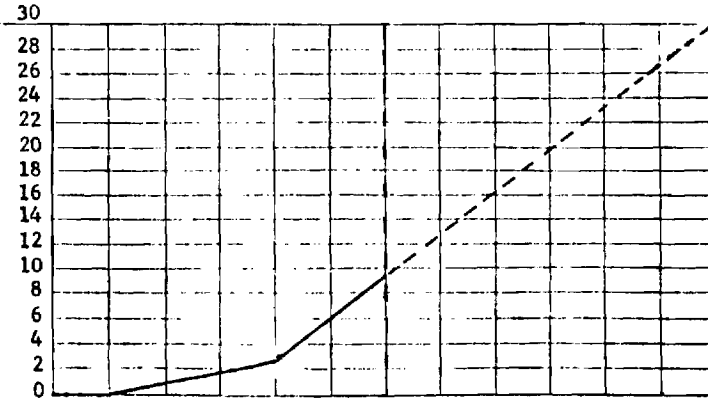
e. Actual Costs Prior FYs: 0

f. Planned Costs Prior FYs: 0

g. Total Estimated Accrued Costs for Contract: 73.44

h. Total Contract Value: 73.44

10. Manpower Status



Manpower		J	J	A	S	O	N	D	J	F	M	A	M
	b. Planned	0	0.88	0.88	0.88	3.43	3.43	3.43	3.43	3.43	3.43	3.43	3.44
	c. Actual	0	0.88	0.88	0.88	3.43	3.43						
	d. Variance	0	0	0	0	0	0						

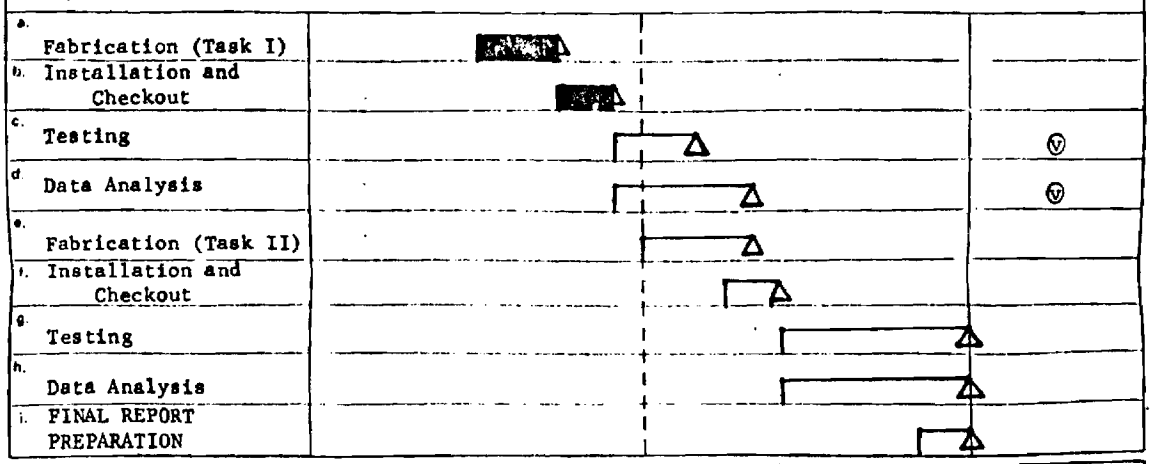
e. Actual Manpower Prior FYs: 0

f. Planned Manpower Prior FYs: 0

g. Total Estimated Manpower for Contract: 30.12

h. Total Contract Manpower: NOT SPECIFIED

11. Major Milestone Status



12. Remarks

SEE TECHNICAL PROGRESS REPORT FOR EXPLANATION OF VARIANCES

13. Signature of [illegible] and Date	14. Signature of Government Technical Representative and Date
Ben T.Zin , [illegible] Investigator, Dec. 5, 1979	

E-16-646

GEORGIA INSTITUTE OF TECHNOLOGY
SCHOOL OF AEROSPACE ENGINEERING
ATLANTA, GEORGIA 30332
Telephone 404-894-3033/3000
Telex: SY2507 GTRI OCA ATL

Ben T. Zinn
Regents Professor
Daniel Guggenheim
School of Aeronautics

January 4, 1979
So

Dr. Ernest Blase
Department of Energy
Washington D.C. 20585

Subject:

Progress Report for period December 1, 1979 through December 31, 1979 for work conducted under DOE Contract Number DE-AS05-79ER 10068.

As mentioned in the previous Progress Report, the initiation of the first phase of the experimental test program was delayed by a slippage in the delivery date of the electrical heating elements from the manufacturer. Several design changes which were made during the manufacturing process seriously compromised the effectiveness of the heating elements which were finally delivered. During this reporting period additional heating elements were purchased locally and a 6000 watt heating unit has been assembled by Georgia Tech personnel. The fabrication and installation of the second electrical heating system is now completed and an operational check-out of the system and components is in progress. Therefore, the experimental test program utilizing the electric heating unit will be initiated in the coming week and a concerted effort will be made to make-up the time lost in the experimental program.

The design and installation of the exhaust and filtration system for the subsequent, coal burning, phase of the experimental program has continued. The exhaust fan and motor, which were long-delay time items, are now on hand and the work has begun on making the electrical hook-up to the fan/motor drive and control system.

Testing with the a previously developed pulsating combustor setup continued during this reporting period. Additional tests, using a charcoal fuel bed located at distances of L/4 and L/2 from the bottom of the tube were conducted. The tests with the combustion bed at L/4 resulted in pulsating combustion while those with the combustion bed at L/2 resulted in steady state combustion. Comparisons of the fuel mass vs. time plots for the

pulsating and steady-state tests confirmed the previous test results which indicated that the mass burning rates for the tested charcoal under pulsating conditions is only slightly higher than the mass burning rate under steady state conditions. Similar comparisons for different size char coals are planned for the future.

The theoretical efforts that are concerned with the determination of the feedback between the combustion process and the tube's oscillations have continued during the reporting period. These efforts are primarily concerned with the development of a theoretical model that could be used as a guide in the development of an experimental procedure for the determination of the above mentioned feedback. These efforts together with the efforts that are concerned with the determination of the efficiency of the pulsating combustor will continue during the next reporting period.

Sincerely,

Ben T. Zinn
Principal Investigator

BTZ/jj

FORM ERDA 52
(2/1/77)

U.S. ENERGY RESEARCH AND DEVELOPMENT ADMIN.

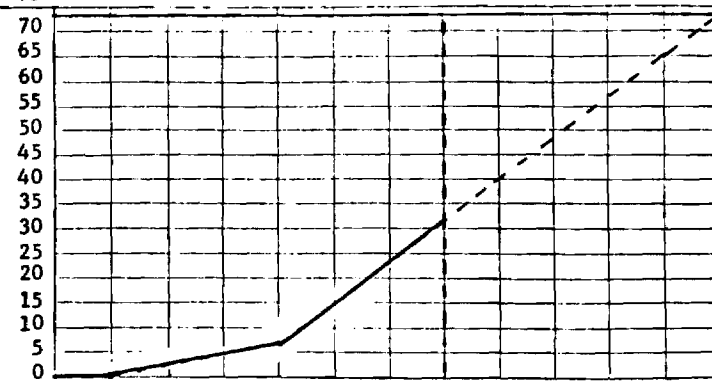
CONTRACT MANAGEMENT SUMMARY R. C.

FORM APPROVED OMB NO. 38-R

1. Contract Identification: Development of a Coal Burning Pulsating Combustor for Power Generation	2. Reporting Period	3. Contract Number: DE-AS05-79ER10068
4. Contractor (name and address): Georgia Tech Research Institute Administration Building Georgia Institute of Technology Atlanta, Georgia 30332		5. Contract Start Date: 1 June 1979 6. Contract Completion Date: 31 May 1980

7. Months	J	J	A	S	O	N	D	J	F	M	A	M	8. FY 79-80

9. Cost Status



Accrued Costs	J	J	A	S	O	N	D	J	F	M	A	M
b. Planned	0	2.15	2.15	2.15	8.37	8.37	8.37	8.37	8.37	8.37	8.37	8.40
c. Actual	0	2.15	2.15	2.15	8.37	8.37	8.37					
d. Variance	0	0	0	0	0	0	0					

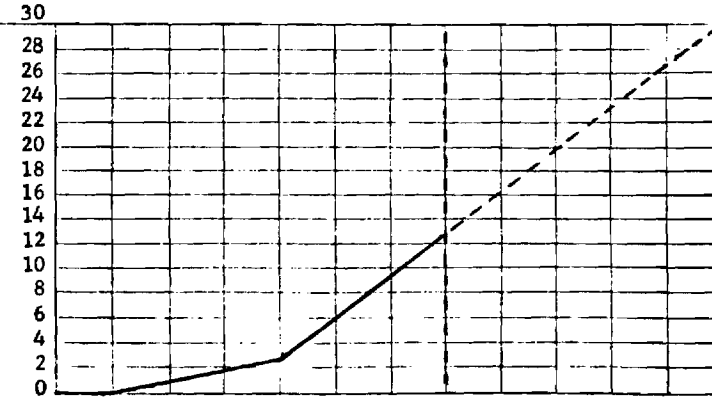
c. Actual Costs Prior FYs: 0

f. Planned Costs Prior FYs: 0

g. Total Estimated Accrued Costs for Contract: 73.44

h. Total Contract Value: 73.44

10. Manpower Status



Manpower	J	J	A	S	O	N	D	J	F	M	A	M
b. Planned	0	0.88	0.88	0.88	3.43	3.43	3.43	3.43	3.43	3.43	3.43	3.44
c. Actual	0	0.88	0.88	0.88	3.43	3.43	3.43					
d. Variance	0	0	0	0	0	0	0					

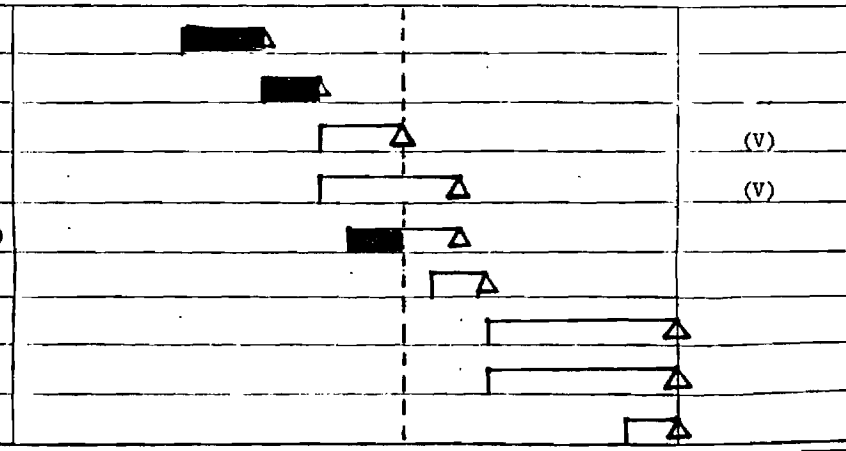
c. Actual Manpower Prior FYs: 0

f. Planned Manpower Prior FYs: 0

g. Total Estimated Manpower for Contract: 30.12

h. Total Contract Manpower: NOT SPECIFIED

11. Major Milestone Status



12. Remarks

See Technical Progress Report for explanation of variances

13. Signature of	14. Signature of Government Technical Representative and Date
Ben T. Zinn, Principal Investigator, Jan 5, 1980	

GEORGIA INSTITUTE OF TECHNOLOGY
SCHOOL OF AEROSPACE ENGINEERING
ATLANTA, GEORGIA 30332
Telephone 404-894-3033 3060
Telex, SY2507 GTRI OC ATL

Ben T. Zinn
Regents Professor
Daniel Guggenheim
School of Aeronautics

February 5, 1980

Dr. Ernest Blase
Department of Energy
Washington D. C. 20585

Subject:

Progress report for period January 1, 1980 through January 31, 1980 for work conducted under DOE Contract DE-A505-79ER10068.

Unfortunately progress on this contract has slowed down during the last reporting period due to the unexpected absence of Mr. T. S. Sheshadri, who has been one of the principal investigators on this project. Mr. Sheshadri went home to India to visit his family during the 1979 Christmas vacation and his request for a return visa to the U.S. was unexpectedly denied by the U.S. Consulate in Madras, India even though Mr. Sheshadri has an approved H-I visa which permits him to conduct research as a nonpermanent resident. Mr. Sheshadri possesses the technical background that is essential for work on this contract and efforts directed at obtaining Mr. Sheshadri a visa are currently underway; both Senator Nunn's office and DOE personnel are assisting us with these efforts. It will be very unfortunate if we shall have to look for a replacement for Mr. Sheshadri in case our efforts to get him a visa for returning to the U.S. fail.

The experimental efforts conducted under this contract involved (a) the determination of the combustor lengths and heat source locations for which pulsating combustion operation is possible and (b) the determination of dependence of the burn rate upon the size of the solid fuel constituents under pulsating and nonpulsating operating conditions. Initial efforts under investigation (a) above involved the utilization of electrical heating elements as the heat source. Unfortunately, the developed electrical heating configuration did not excite pulsations in any of the tested combustor configurations. The latter was apparently caused by blockage by the metal heating elements of upward flow in the combustor. Consequently, a bed of burning wood chips was used as a replacement for the electrical heat source and a pulsating mode of combustion was established in the combustor. Efforts are currently underway, utilizing the burning woodchips, to determine the range of combustor lengths and combustion bed locations for which pulsating combustion is possible.

The tests to determine the dependence of the burn rate upon the size of the solid fuel constituents were conducted in a previously developed 6.5 inch diameter pulsating combustor utilizing charcoal as the fuel. Todate, tests measuring the burn rate of "full size" and "quarter size" charcoal elements have been completed and the results are currently being analyzed.

Progress has been made during the reporting period on the design and fabrication of the combustion section of the apparatus, the coal combustion bed, the combustion viewing window, the coal feed system and the mass loss measurement system. The design of these components is almost finished and their fabrication is well on its way to completion.

Efforts have been initiated by Dr. Pasternak, who is an analytical chemist, on the planning of the measurement system for the determination of the CO and NO_x concentrations produced during the combustion of coal with and without pulsations. This work will continue during the next reporting period.

Sincerely,

Ben T. Zinn
Principal Investigator

BTZ/jj

FORM ERDA 52
(2-77)

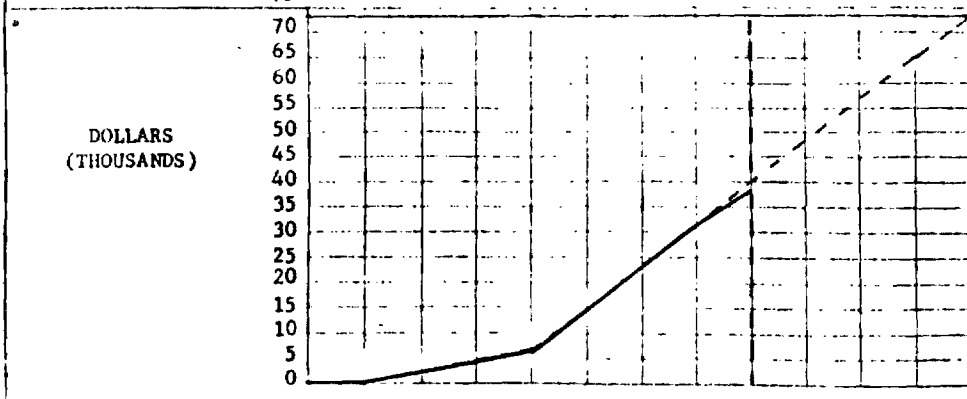
U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

CONTRACT MANAGEMENT SUMMARY REPORT

1 Contract Identification: Development of a Coal Burning Pulsating Combustor for Power Generation	2 Reporting Period	3 Contract Number: DE-AS05-79ER10068
4 Contractor (name and address): Georgia Tech Research Institute, Administration Building, Georgia Institute of Technology, Atlanta, Georgia 30332		5 Contract Start Date: 1 June 1979
		6 Contract Completion Date: 31 May 1980

7 Months	J	J	A	S	O	N	D	J	F	M	A	M	8 FY 79-80

9 Cost Status



Accrued Costs													
b Planned	0	2.15	2.15	2.15	8.37	8.37	8.37	8.37	8.37	8.37	8.37	8.40	
c Actual	0	2.15	2.15	2.15	8.37	8.37	8.37	7.50					
d Variance	0	0	0	0	0	0	0	.87					

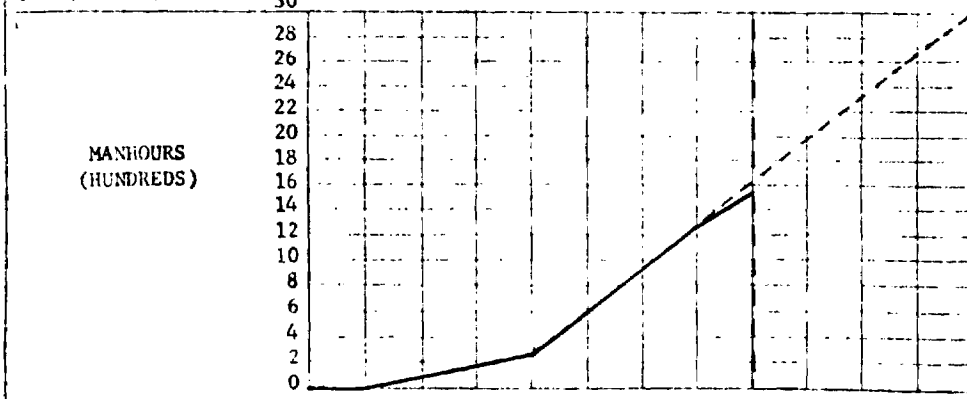
a Actual Costs Prior FYs: 0

e Planned Costs Prior FYs: 0

g Total Estimated Accrued Costs for Contract: 73.44

h Total Contract Value: 73.44

10 Manpower Status



Manpower													
b Planned	0	0.88	0.88	0.88	3.43	3.43	3.43	3.43	3.43	3.43	3.43	3.44	
c Actual	0	0.88	0.88	0.88	3.43	3.43	3.43	2.36					
d Variance	0	0	0	0	0	0	0	1.07					

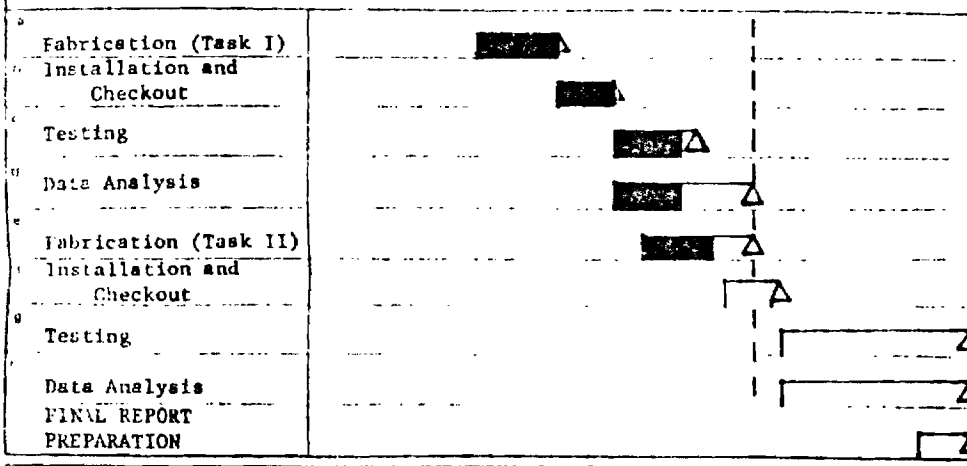
a Actual Manpower Prior FYs: 0

e Planned Manpower Prior FYs: 0

g Total Estimated Manpower for Contract: 30.12

h Total Contract Manpower: NOT SPECIFIED

11 Major Milestone Status



12. Remarks: See Technical Progress Report for details of variances.

13 Signature / Date	14 Signature of Government Technical Representative and Date
Ben T. Zinn, Principal Investigator, Jan. 5, 1980	

E16-647

GEORGIA INSTITUTE OF TECHNOLOGY
SCHOOL OF AEROSPACE ENGINEERING
ATLANTA, GEORGIA 30332
Telephone 404-894-3033/3000
Telex: SY2507 GTRI OCA ATL

Ben T. Zinn
Regents Professor
Daniel Guggenheim
School of Aeronautics

March 7, 1980

Dr. Ernest Blase
Department of Energy
Washington D.C. 20585

Subject: Progress report for period February 1, 1980 through February 29, 1980 for work conducted under DOE Contract DE-A505-79ER 10068.

As reported in the previous progress report, Mr. T. S. Sheshadri, one of the principal investigators on this project has been detained in India for the past 2 1/2 months because his request for a return visa to the United States was denied by the U.S. Consulate in Madras, India. The absence of Mr. Sheshadri is reflected in the variance in the cost and manhour status of the contract as indicated in the Management Summary Report. His absence is also reflected in the time schedule of major milestones. Although considerable progress was made during this reporting period in initiating the Task II work program, some work in data analysis associated with Task I has been deferred to concide with the Task II effort. This is considered a more efficient method for getting the contract work on schedule considering the manpower currently available. Efforts to resolve the problems associated with Mr. Sheshadri's visa and subsequent return to the United States are continuing through various channels.

The design and fabrication of the combustor section with a fuel feed system and viewing window has been completed. The design of the mass loss measurement system has been completed and fabrication is in progress.

The experimental efforts during this reporting period were concentrated on determining the range of combustor lengths and combustor bed locations for which pulsating combustion is possible using both wood and coal as fuel. These preliminary tests indicated that a pulsating mode of combustion is possible with the fuel bed located almost any place in the lower half of the combustor tube. This statement is vague as the finite length of the flame prevent us at this tme from determining exactly the precise locations of heat addition.

The tube pulsations at combustor locations near positions 0 (i.e., the lower end of the tube) and L/2 exhibit a wave form containing higher harmonics of the natural frequency of the tube. These higher harmonics occur only at fuel bed locations near position 0 and L/2 and they are not evident when the combustor is located near the L/4 position. No pulsations were observed where the fuel bed was located anyplace between L/2 to L, the upper end of the tube.

Progress has continued on the development of the measurement system for the determination of the CO and NO_x concentrations produced during the combustion of coal.

Sincerely,

Ben T. Zinn
Principal Investigator

BTZ/jj

FORM ERDA 53
(2/1/77)

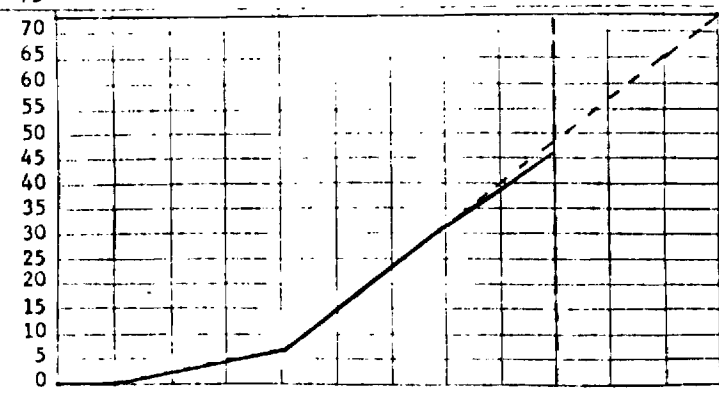
U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

CONTRACT MANAGEMENT SUMMARY REPORT

1 Contract Identification: Development of a Coal Burning Pulsating Combustor for Power Generation	2 Reporting Period	3 Contract Number: DE-AS05-79ER10068
4 Contractor (name and address): Georgia Tech Research Institute, Administration Building, Georgia Institute of Technology, Atlanta, Georgia 30332		5 Contract Start Date: 1 June 1979 6 Contract Completion Date: 31 May 1980

7 Months	J	J	A	S	O	N	D	J	F	M	A	M	8 FY 79-80

9 Cost Status



Accrued Costs													
b Planned	0	2.15	2.15	2.15	8.37	8.37	8.37	8.37	8.37	8.37	8.37	8.40	
c Actual	0	2.15	2.15	2.15	8.37	8.37	8.37	7.50	7.50				
d Variance	0	0	0	0	0	0	0	.87	.87				

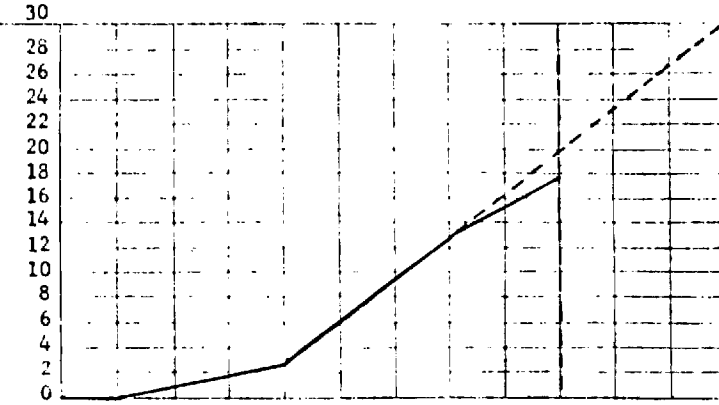
e Actual Costs Prior FYs: 0

f. Planned Costs Prior FYs: 0

g. Total Estimated Accrued Costs for Contract: 73.44

h. Total Contract Value: 73.44

10 Manpower Status



Manpower													
b Planned	0	0.88	0.88	0.88	3.43	3.43	3.43	3.43	3.43	3.43	3.43	3.44	
c Actual	0	0.88	0.88	0.88	3.43	3.43	3.43	2.36	2.36				
d Variance	0	0	0	0	0	0	0	1.07	1.07				

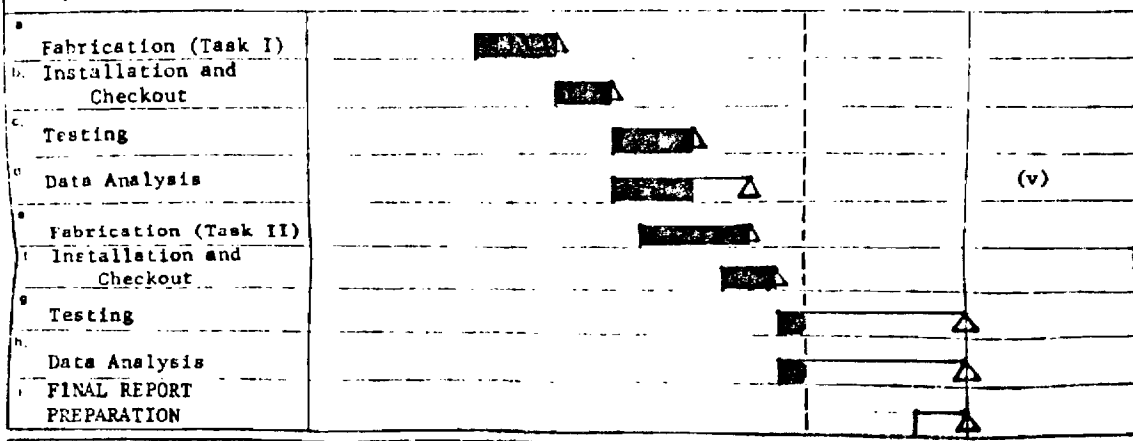
e Actual Manpower Prior FYs: 0

f Planned Manpower Prior FYs: 0

g Total Estimated Manpower for Contract: 30.12

h Total Contract Manpower: NOT SPECIFIED

11 Major Milestone Status



12 Remarks

See Technical Progress Report for details of variances.

13 [illegible] and Date	14 Signature of Government Technical Representative and Date
Ben T. Zinn, Principal Invest[illegible] March 5,1980	

FORM ERDA 52
(2/1/77)

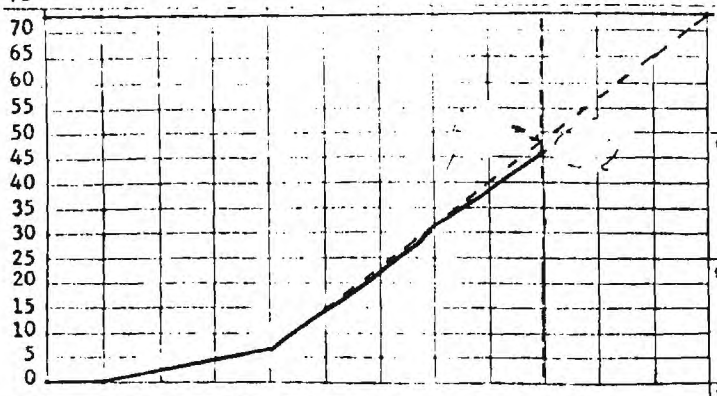
U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

CONTRACT MANAGEMENT SUMMARY REPORT

1. Contract Identification: Development of a Coal Burning Pulsating Combustor for Power Generation	2. Reporting Period	3. Contract Number: DE-AS05-79ER10068
4. Contractor (name and address): Georgia Tech Research Institute, Administration Building, Georgia Institute of Technology, Atlanta, Georgia 30332		5. Contract Start Date: 1 June 1979
		6. Contract Completion Date: 31 May 1980

7. Months	J	J	A	S	O	N	D	J	F	M	A	M	8. FY 79-80

9. Cost Status



Accrued Costs													
b. Planned	0	2.15	2.15	2.15	8.37	8.37	8.37	8.37	8.37	8.37	8.37	8.40	
c. Actual	0	2.15	2.15	2.15	8.37	8.37	8.37	7.50	7.50				
d. Variance	0	0	0	0	0	0	0	.87	.87				

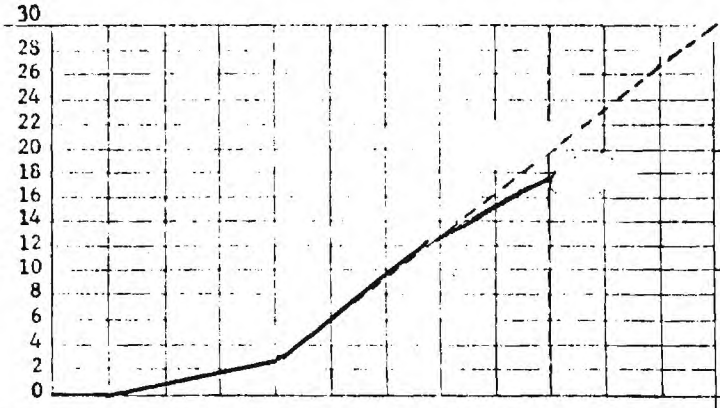
e. Actual Costs Prior FYs: 0

f. Planned Costs Prior FYs: 0

g. Total Estimated Accrued Costs for Contract: 73.44

h. Total Contract Value: 73.44

10. Manpower Status



Manpower													
b. Planned	0	0.88	0.88	0.88	3.43	3.43	3.43	3.43	3.43	3.43	3.43	3.44	
c. Actual	0	0.88	0.88	0.88	3.43	3.43	3.43	2.36	2.36				
d. Variance	0	0	0	0	0	0	0	1.07	1.07				

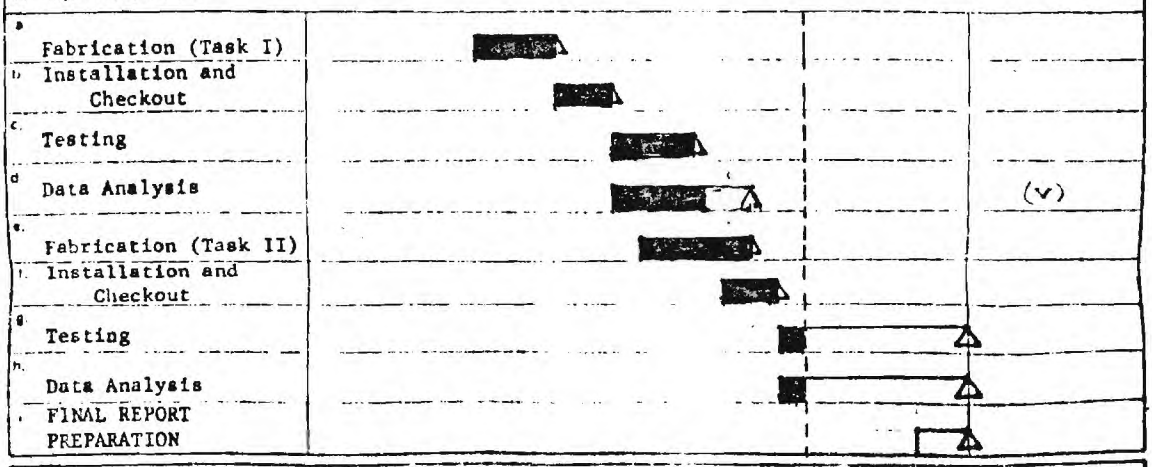
e. Actual Manpower Prior FYs: 0

f. Planned Manpower Prior FYs: 0

g. Total Estimated Manpower for Contract: 30.12

h. Total Contract Manpower: NOT SPECIFIED

11. Major Milestone Status



12. Remarks: See Technical Progress Report for details of variances.

13. Signature of Contractor's Project Manager and Date	14. Signature of Government Technical Representative and Date
Principal Investigator March 5, 1980	

GEORGIA INSTITUTE OF TECHNOLOGY
SCHOOL OF AEROSPACE ENGINEERING
ATLANTA, GEORGIA 30332
Telephone 404 894-3033/3000
Telex: SY2507 GTRI OCA ATL

Ben T. Zinn
Regents Professor
Daniel Guggenheim
School of Aeronautics

April 8, 1980

Dr. Ernest Blase
Department of Energy
Washington, D.C. 20585

Subject: Progress report for the period March 1 through March 31, 1980 for work conducted under DOE Contract DE-A505-79ER 10068.

Efforts to resolve the problems associated with Mr. T. S. Sheshadri's visa have reached a virtual stalemate and the prospects for his return to the United States in the near future is not promising, however; the U.S. Consulate in India has agreed to review the case once again. Mr. Sheshadri's absence continues to be reflected in the variance in the cost and manpower status of the contract as indicated in the Management Summary Report and also in the variance indicated in the time schedule of major milestones. Unless Mr. Sheshadri's absence is positively resolved in the near future, we shall be forced to look for a suitable replacement.

The experimental efforts conducted during this reporting period concentrated on determining the relative burning rates of coal with and without pulsations. The experiments were conducted in a 9 feet long combustor and the combustion bed was located at the L/4 position (i.e., one-quarter of the tube length measured from the lower end of the tube) during both the pulsating and non-pulsating tests. During the non-pulsating tests a small circular opening, approximately $0.2 cm^2$ in area, in the coal feed door was sufficient for damping the oscillations and allowed for a non-pulsating burning at the L/4 position.

All tests were 30 minutes in duration and were initiated by igniting 50 grams of wood (for starter) and 400 grams of coal. Each time the weight of the combustibles in the load reached 400 grams, 50 grams of coal were added to the combustion bed. All coal samples used ranged in size from approximately 1 cubic centimeter to 15 cubic centimeters and weighed in the range from 1.3 to 20 grams each.

The burning rates for the pulsating and non-pulsating burning was roughly 25 grams per minute and the burning rate for both cases was essentially the same. One major difference between burning with and without pulsation was noted however. The smoke discharge during burning with pulsation is dramatically lower than the smoke discharge when no pulsations are present, suggesting a more complete combustion process during pulsating combustion.

Efforts to measure the generated smoke concentrations and determine the efficiency of the combustion process with and without pulsations are in progress. Finally, efforts to develop a measurement system for determining pollutant concentrations in the combustor's exhaust are also in progress.

Sincerely,

Ben T. Zinn

BTZ/jj

FORM ERDA 52
(2-1-77)

U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

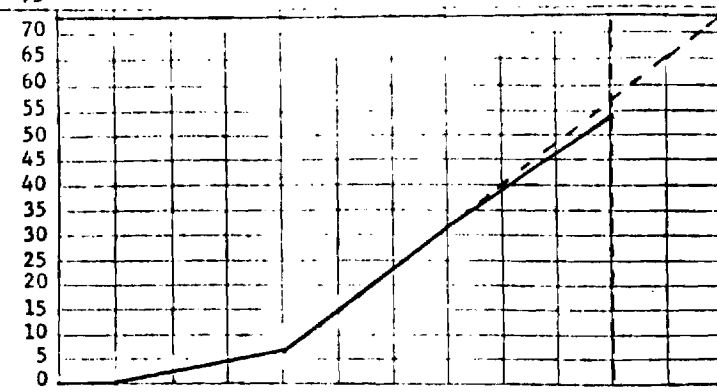
CONTRACT MANAGEMENT SUMMARY REPORT

1 Contract Identification: Development of a Coal Burning Pulsating Combustor for Power Generation	Reporting Period	3 Contract Number: DE-AS05-79ER10068
4 Contractor (name and address): Georgia Tech Research Institute, Administration Building, Georgia Institute of Technology, Atlanta, Georgia 30332		5 Contract Start Date: 1 June 1979
		6 Contract Completion Date: 31 May 1980

7 Months	J	J	A	S	O	N	D	J	F	M	A	M	8 FY 79-80

9 Cost Status

DOLLARS (THOUSANDS)



Accrued Costs													
b. Planned	0	2.15	2.15	2.15	8.37	8.37	8.37	8.37	8.37	8.37	8.37	8.40	
c. Actual	0	2.15	2.15	2.15	8.37	8.37	8.37	7.50	7.50	7.50			
d. Variance	0	0	0	0	0	0	0	.87	.87	.87			

e. Actual Costs Prior FYs: 0

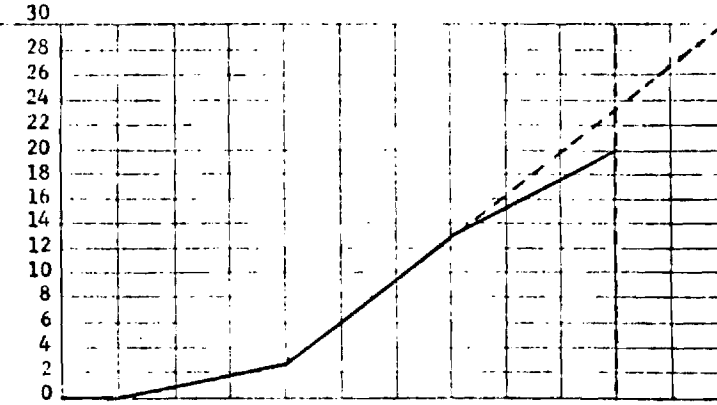
f. Planned Costs Prior FYs: 0

g. Total Estimated Accrued Costs for Contract: 73.44

h. Total Contract Value: 73.44

10 Manpower Status

MANHOURS (HUNDREDS)



Manpower													
b. Planned	0	0.88	0.88	0.88	3.43	3.43	3.43	3.43	3.43	3.43	3.43	3.44	
c. Actual	0	0.88	0.88	0.88	3.43	3.43	3.43	2.36	2.36	2.36			
d. Variance	0	0	0	0	0	0	0	1.07	1.07	1.07			

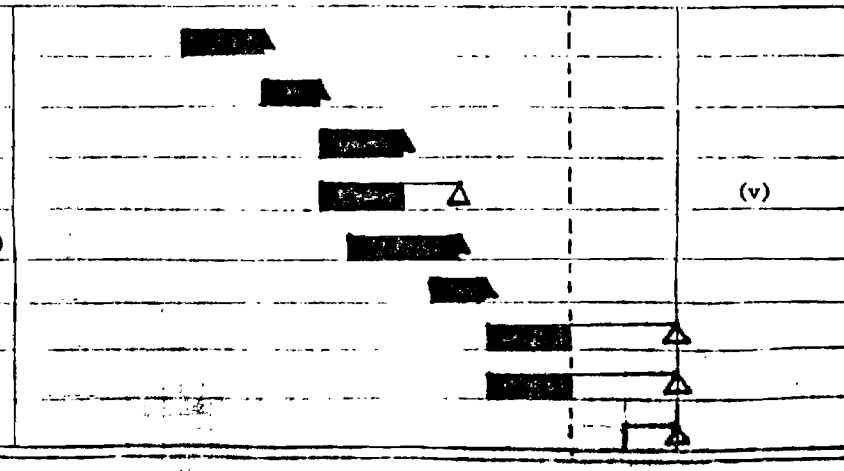
e. Actual Manpower Prior FYs: 0

f. Planned Manpower Prior FYs: 0

g. Total Estimated Manpower for Contract: 30.12

h. Total Contract Manpower: NOT SPECIFIED

11 Major Milestone Status



12 Remarks

See Technical Progress Reoirt for details of variances

13 Signature and Date

Ben T. Zinn, Principal Investigator, April 8, 1980

14 Signature of Government Technical Representative and Date

GEORGIA INSTITUTE OF TECHNOLOGY
SCHOOL OF AEROSPACE ENGINEERING
ATLANTA, GEORGIA 30332
Telephone 404 894-3033 3000
Telex: SY2507 GTRI OCA ATL

Ben T. Zinn
Regents Professor
Daniel Guggenheim
School of Aeronautics

May 6, 1980

Dr. Ernest Blase
Department of Energy
Washington, D.C. 20585

Subject: Progress report for the period April 1 through April 30, 1980 for work conducted under DOE Contract DE-A505-79ER 10068.

No additional information concerning the status of Mr. T. S. Sheshadri has been received at Georgia Tech during this reporting period. Mr. Sheshadri's absence continues to be reflected in the variance in the cost and manpower status as indicated in the Management Summary Report.

The tests conducted during this reporting period concentrated on the development of gas sampling technique for the determination of comparative levles of carbon monoxide (CO) concentrations in the exhaust gas during operations with and without pulsations. These tests also established testing procedures and operating conditions required for the more extensive exhaust gas sampling and analysis program to follow.

The tests were conducted in the 9 ft. long combustor tube configuration with the combustor bed located at the L/4 position, one-quarter of the tube length measured from the lower end of the tube. The weight of the coal in the combustion bed was maintained between 250 and 350 grams during the testing sequences by adding additional coal in 100 grain increments every 4 minutes. In addition to gas sampling, the exhaust gas temperature was measured during each test and the dynamic pressure level and frequency was monitored during tests where pulsations were present.

The fabrication of a more accurate combustor bed mass measurement system is near completion. When this system is installed a more comprehensive gas analysis program including the determination of pollutant concentrations will be initiated.

A paper entitled "Application of Pulsating Combustion in the Burning of Solid Fuels" has been completed during the last reporting period. This paper describes initial efforts under this program and it will appear in the Proceedings of a Conference on Pulsating Combustion that was held in November 1979 at the Argonne National Laboratory.

Finally, contacts for future collaboration have been established with the Georgia Power Company which has kindly agreed to provide this group with coal samples of known properties as well as assist with the analysis of tested coal samples.

Sincerely,

Ben T. Zinn
Principal Investigator

BTZ/jj

FORM ERDA 52
(2-1/77)

U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

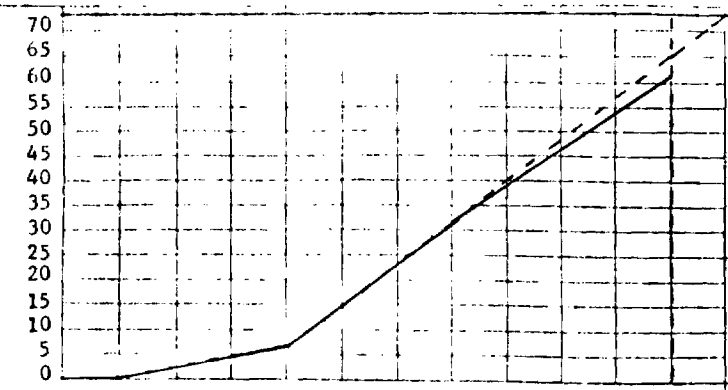
CONTRACT MANAGEMENT SUMMARY REPORT

1 Contract Identification: Development of a Coal Burning Pulsating Combustor for Power Generation	Reporting Period
2 Contractor (name and address): Georgia Tech Research Institute, Administration Building, Georgia Institute of Technology, Atlanta, Georgia 30332	3 Contract Number: DE-AS05-79ER10068
	5 Contract Start Date: 1 June 1979
	6 Contract Completion Date: 31 May 1980

7 Months	J	J	A	S	O	N	D	J	F	M	A	M	8 FY 79-80

9 Cost Status

DOLLARS (THOUSANDS)



Accrual Costs	J	J	A	S	O	N	D	J	F	M	A	M
b Planned	0	2.15	2.15	2.15	8.37	8.37	8.37	8.37	8.37	8.37	8.37	8.40
c Actual	0	2.15	2.15	2.15	8.37	8.37	8.37	7.50	7.50	7.50	7.50	
d Variance	0	0	0	0	0	0	0	.87	.87	.87	.87	

e. Actual Costs Prior FYs: 0

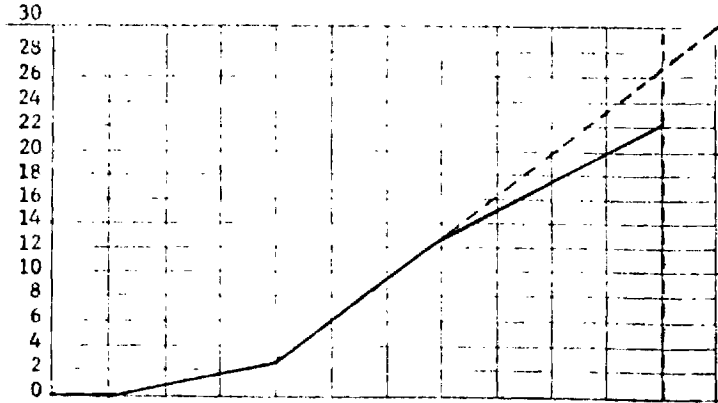
f. Planned Costs Prior FYs: 0

g. Total Estimated Accrued Costs for Contract: 73.44

h. Total Contract Value: 73.44

10 Manpower Status

MANHOURS (HUNDREDS)



Manpower	J	J	A	S	O	N	D	J	F	M	A	M
b Planned	0	0.88	0.88	0.88	3.43	3.43	3.43	3.43	3.43	3.43	3.43	3.44
c Actual	0	0.88	0.88	0.88	3.43	3.43	3.43	2.36	2.36	2.36	2.36	
d Variance	0	0	0	0	0	0	0	1.07	1.07	1.07	1.07	

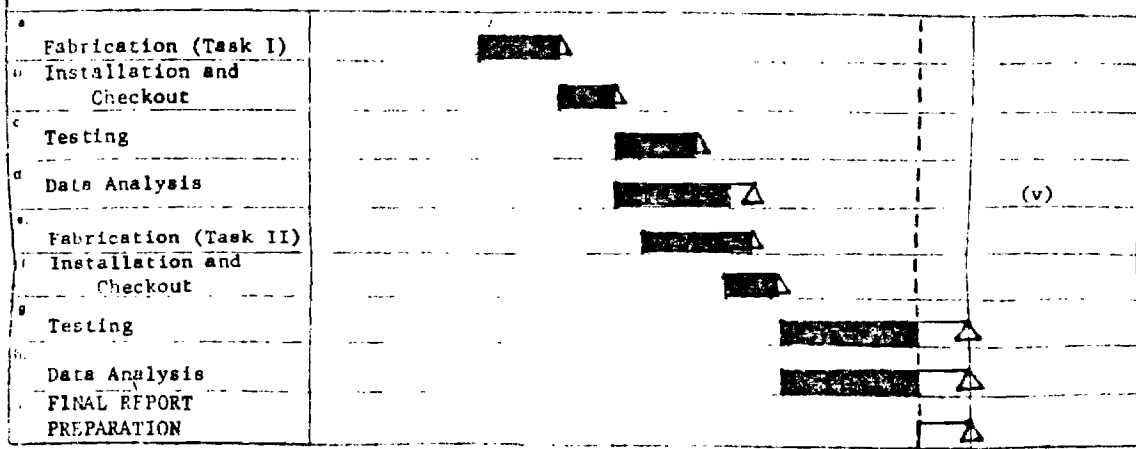
e. Actual Manpower Prior FYs: 0

f. Planned Manpower Prior FYs: 0

g. Total Estimated Manpower for Contract: 30.12

h. Total Contract Manpower: NOT SPECIFIED

11 Major Milestone Status



12 Remarks

See Technical Progress Report for details of variances

13 Signature of Contractor's Project Manager and Date	14 Signature of Government Technical Representative and Date
Ber [illegible] Investigator, May 5, 1980	

E16-646

GEORGIA INSTITUTE OF TECHNOLOGY
SCHOOL OF AEROSPACE ENGINEERING
ATLANTA, GEORGIA 30332
Telephone 404-894-3033/3000
Telex: SY2507 GTRI OCA ATL

Ben T. Zinn
Regents Professor
Daniel Guggenheim
School of Aeronautics

June 6, 1980

Dr. Ernest Blase
Department of Energy
Washington, D.C. 20585

Subject: Progress report for the period May 1 through May 31, 1980 for work conducted under DOE Contract DE-A505-79ER 10068.

While the formal completion of this contract is May 31, 1980, a request has been sent to DOE to extend this contract through September 30, 1980 with no additional charges to DOE. The extension of this contract was necessitated by the fact that Georgia Tech did not receive this contract until September 1, 1979 and by the refusal of the U.S. Consul in Madras, India to give Dr. Sheshadri, who was one of the principal investigators on this contract, a visa to come back to the U.S. after Dr. Sheshadri traveled to India during the Christmas break. The latter matter has been discussed in our previous monthly reports to DOE and we are still hoping that Dr. Sheshadri will be able to return to the United States and continue his contributions to the efforts conducted under this contract. Mr. Sheshadri's absence continues to be reflected in the indicated changes in the Cost and Manpower Status Report and in the changes in the time schedule of the Major Milestone Status.

During the last reporting period, the fabrication of the digitized-continuous mass measurement system was completed and the installation and check out of this system is currently in progress. This system is expected to provide this program with the capability for continuous measurment of the burn rate of the coal during a test run.

As indicated in our original proposal to DOE, it is also expected that cooling the hot combustion products at a distance of 3L/4 from the bottom of the combustor tube will enhance the pulsations in the combustor. In order to further pursue this idea, a water heater has been designed during the last reporting period and it will be soon added to the developed pulsating combustor in order to test its effectiveness.

During earlier phases of this program, coal was fed to the combustion bed through a circular port located in the wall of the combustor a few inches above the burning bed. When the coal was not being fed into the combustor, the port was kept closed by a hinged circular door. Experience has shown, however, that whenever the hinged door was opened the pulsations would cease in the combustor. Also, this method of adding coal did not allow for a continuous coal feed. In order to alleviate the above mentioned difficulties, a continuous coal feed system has been designed during the last reporting period and the necessary drawings are currently being prepared for our machine shop.

Tests conducted during the last reporting period were concerned with the determination of the dependence of the performance of the pulsating combustor upon the average particle size of the burned coal. Tests were conducted with several coal batches having different average particle size. These tests have indicated that pulsating combustion is possible only when the average particle size is larger than a given minimum; the size of this minimum is yet to be determined. These tests have shown that when the average particle size is too small, the coal bed becomes too compact, resulting in a decrease of heat addition to the flow and an increase in the viscous losses associated with the flow through the coal bed. Both effects tend to decrease the possibility of initiating and maintaining pulsations in the tube. Since all the implications of the results obtained in this series of tests have not yet been resolved, the dependence of pulsating combustion operation upon the average coal size will be further considered in the future.

Sincerely,

Ben T. Zinn
Principal Investigator

BTZ/jj

FORM ERDA 52
(2-77)

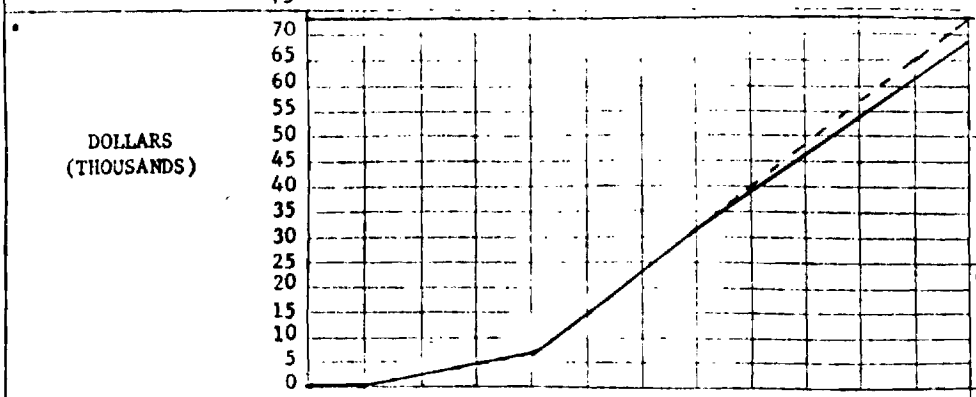
U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

CONTRACT MANAGEMENT SUMMARY REPORT

1 Contract Identification: Development of a Coal Burning Pulsating Combustor for Power Generation	2 Reporting Period	3 Contract Number: DE-AS05-79ER10068
4 Contractor (name and address): Georgia Tech Research Institute, Administration Building, Georgia Institute of Technology, Atlanta, Georgia 30332		5 Contract Start Date: 1 June 1979
		6 Contract Completion Date: 31 May 1980

7 Months	J	J	A	S	O	N	D	J	F	M	A	M	8 FY 79-80

9 Cost Status



e. Actual Costs Prior FYs: 0

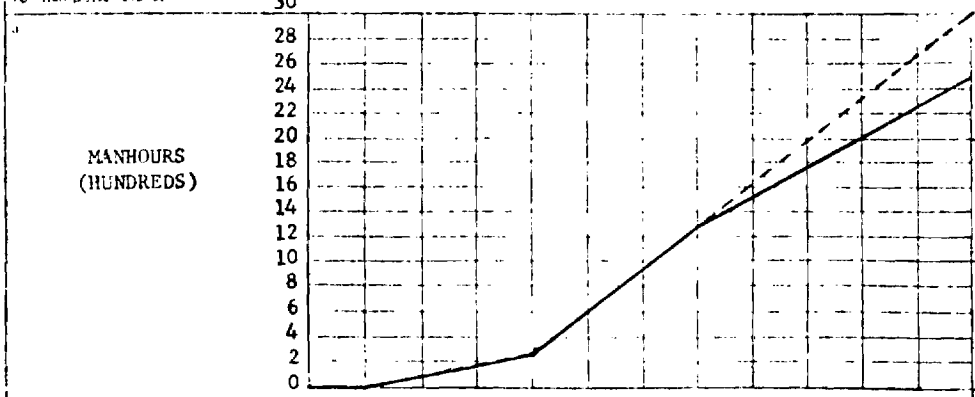
f. Planned Costs Prior FYs: 0

g. Total Estimated Accrued Costs for Contract: 73.44

h. Total Contract Value: 73.44

Accrued Costs													
b. Planned	0	2.15	2.15	2.15	8.37	8.37	8.37	8.37	8.37	8.37	8.37	8.40	
c. Actual	0	2.15	2.15	2.15	8.37	8.37	8.37	7.50	7.50	7.50	7.50	7.50	
d. Variance	0	0	0	0	0	0	0	.87	.87	.87	.87	.87	

10 Manpower Status



i. Actual Manpower Prior FYs: 0

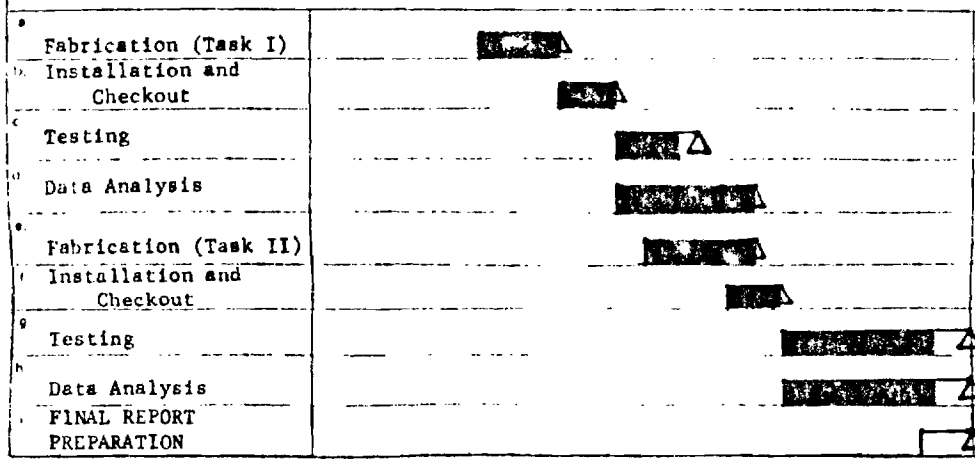
j. Planned Manpower Prior FYs: 0

k. Total Estimated Manpower for Contract: 30.12

l. Total Contract Manpower: NOT SPECIFIED

Manpower													
b. Planned	0	0.88	0.88	0.88	3.43	3.43	3.43	3.43	3.43	3.43	3.43	3.44	
c. Actual	0	0.88	0.88	0.88	3.43	3.43	3.43	2.36	2.36	2.36	2.36	2.36	
d. Variance	0	0	0	0	0	0	0	1.07	1.07	1.07	1.07	1.07	

11 Major Milestone Status



12 Remarks

See Technical Progress Report for details of variance

13 Name and Date	14 Signature of Government Technical Representative and Date
Ben T. Zinn, Principal Investigator, June 6, 1980.	

E16-646

FORM ERDA 52
(2-77)

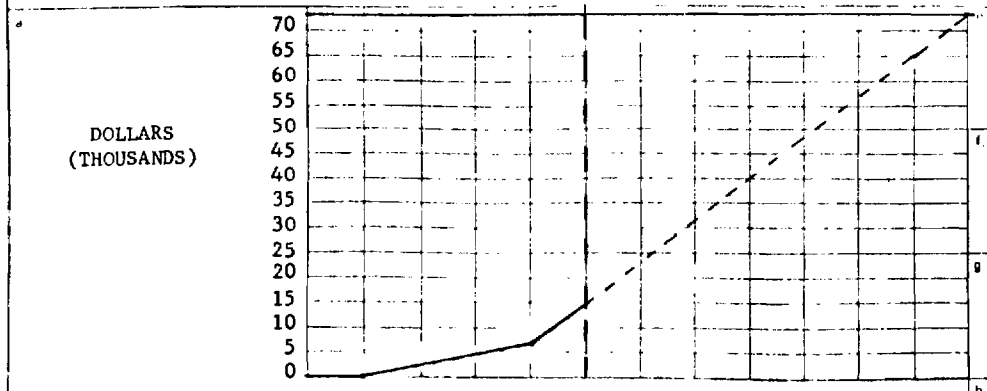
U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

CONTRACT MANAGEMENT SUMMARY REPORT

1 Contract Identification: Development of a Coal Burning Pulsating Combustor for Power Generation	2 Reporting Period: 1 Oct. - 31 Oct.	3 Contract Number: DE-AS05-79ER10068
4 Contractor (name and address): Georgia Tech Research Institute Administration Building Georgia Institute of Technology Atlanta, Georgia 30332		5 Contract Start Date: 1 June 1979 6 Contract Completion Date: 31 May 1980

7 Months: J | J | A | S | O | N | D | J | F | M | A | M — 8 FY 79-80

9 Cost Status



		J	J	A	S	O	N	D	J	F	M	A	M
Accrued Costs	b Planned	0	2.15	2.15	2.15	8.37	8.37	8.37	8.37	8.37	8.37	8.37	8.40
	c Actual	0	2.15	2.15	2.15	8.37							
	d Variance	0	0	0	0	0							

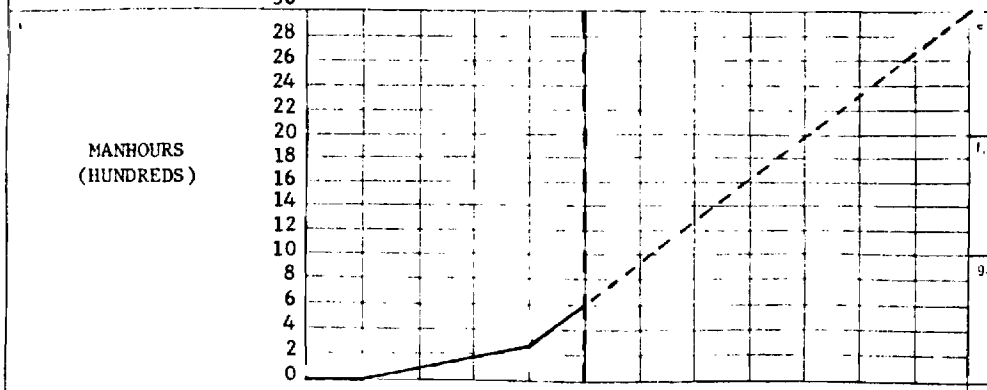
a Actual Costs Prior FYs: 0

e Planned Costs Prior FYs: 0

g Total Estimated Accrued Costs for Contract: 73.44

h Total Contract Value: 73.44

10 Manpower Status



		J	J	A	S	O	N	D	J	F	M	A	M
Manpower	b Planned	0	0.88	0.88	0.88	3.43	3.43	3.43	3.43	3.43	3.43	3.43	3.44
	c Actual	0	0.88	0.88	0.88	3.43							
	d Variance	0	0	0	0	0							

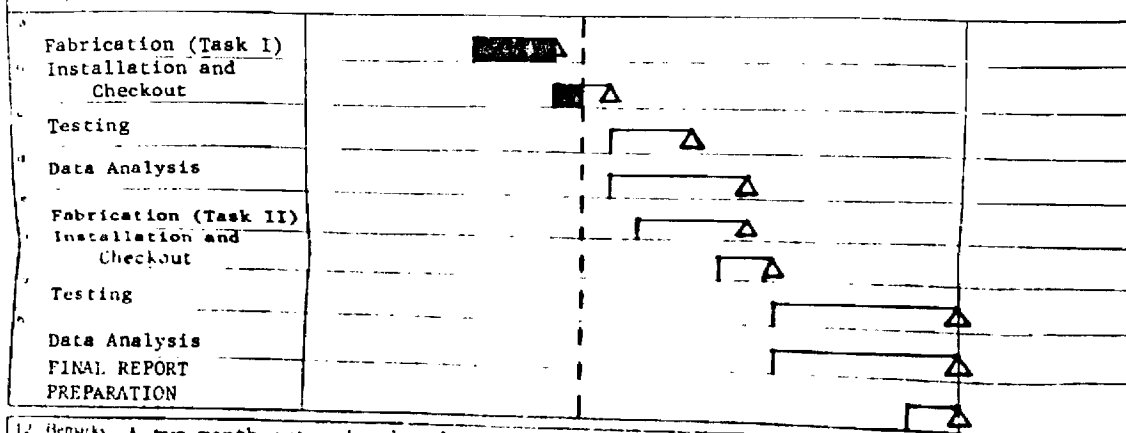
a Actual Manpower Prior FYs: 0

f Planned Manpower Prior FYs: 0

g Total Estimated Manpower for Contract: 30.12

h Total Contract Manpower: NOT SPECIFIED

11 Major Milestone Status



12 Remarks: A two month extension has been requested, with no change in contact funding. The extension will off-set the initial two month delay in contract start date notification.

13 Signature: Ben T. Zinn, Principal Investigator -Nov. , 1979

14 Signature of Government Technical Representative and Date

E16-676

GEORGIA INSTITUTE OF TECHNOLOGY
SCHOOL OF AEROSPACE ENGINEERING
ATLANTA, GEORGIA 30332
Telephone 404-894-3033/3000
Telex: SY2507 GTRI OCA ATL

Ben T. Zinn
Regents Professor
Daniel Guggenheim
School of Aeronautics

July 7, 1980

Dr. Ernest Blase
Department of Energy
Washington, D.C. 20585

Subject: Progress report for the period June 1 through June 30, 1980 for work conducted under DOE Contract DE-A505-79ER 10068

The contract management Summary Report has been revised to reflect a four month "no-cost" contract extension which was discussed in the previous progress report.

As mentioned in the last progress report, a continuous coal feed mechanism has been designed. A test simulating the presence of the feed tube just above the coal bed has been conducted and there was no change in the pulsations in the combustor. The necessary drawings have been completed and the fabrications and installation of this system will take place during the next reporting period.

A soot sampling and measurement system has been discussed and the design criteria is currently being developed. A DISA type 55D01 anemometer unit with a TSI hot-film transducer is currently being used in order to provide velocity profiles in the bottom section of the combustor.

Mainly because of streamline distortion, an isokinetic probe is needed for determining pollutant concentrations in the combustor's exhaust. The laboratory has a gas sampling probe but it will not fit the requirements of this problem. Studies are being conducted in order to make modifications in this probe so that it can be employed.

During the next period tests will be performed to determine the coal feed rate necessary to maintain quasi-steady conditions in the system. This will provide one of the basic steps for the determination of the efficiency of the combustor. The major thrust of the immediate testing to be conducted will be to establish the measurement criteria and the parameters required to obtain representative combustion efficiences for the combustion system.

Sincerely,

for Ben T. Zinn
Principal Investigator

BTZ/jj

ERDA 5[illegible]

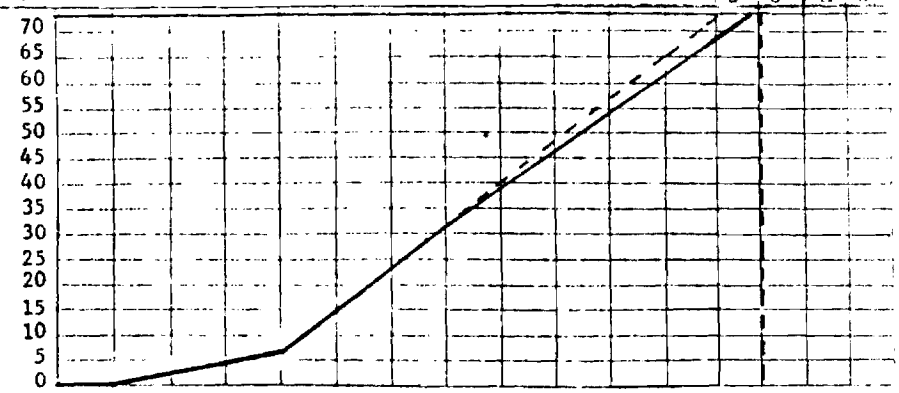
U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

CONTRACT MANAGEMENT SUMMARY REPORT (REVISED 7/15/80)

1 Contract Identification: Development of a Coal Burning Pulsating Combustor for Power Generation	2 Reporting Period	3 Contract Number: DE-AS05-79ER10061
4 Contractor (name and address): Georgia Tech Research Institute, Administration Building, Georgia Institute of Technology, Atlanta, Georgia 30332		5 Contract Start Date: 1 June 1979
		6 Contract Completion Date: 31 May 1980

7 Months: J J A S O N D J F M A M | 8 FY 79-80 | EXTENSION J J A S

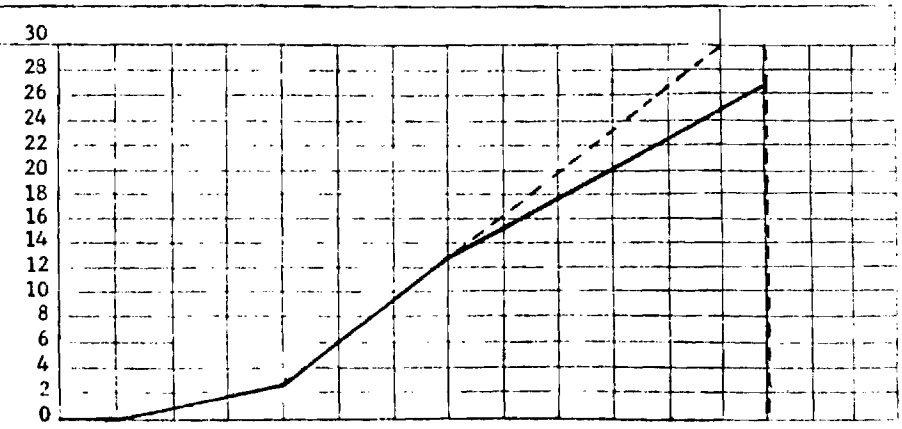
9 Cost Status



h Total Contract Value: 73.44

Accrued Costs																	
	b Planned	0	2.15	2.15	2.15	8.37	8.37	8.37	8.37	8.37	8.37	8.37	8.40	0	0	0	0
	c Actual	0	2.15	2.15	2.15	8.37	8.37	8.37	7.50	7.50	7.50	7.50	7.50	4.38			
	d Variance	0	0	0	0	0	0	0	.87	.87	.87	.87	.90	0			

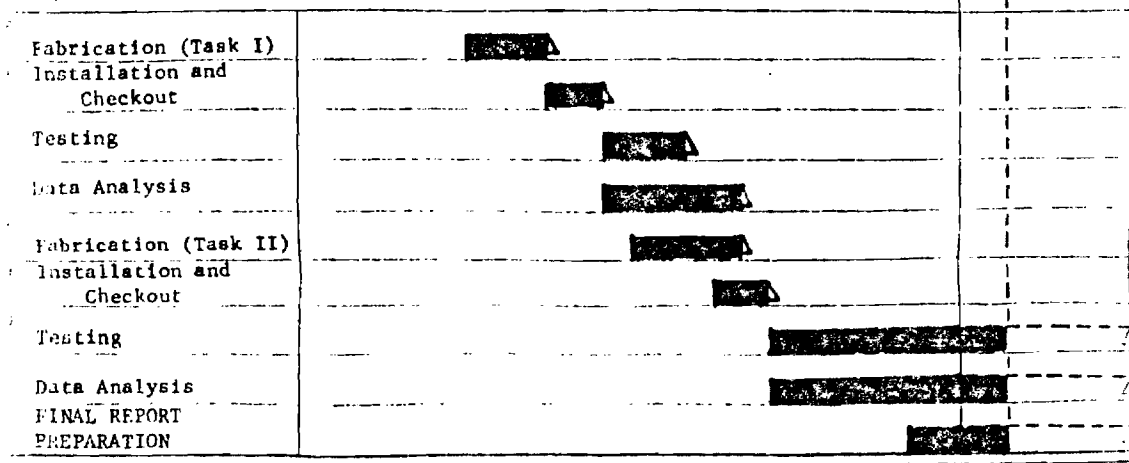
10 Manpower Status



g Total Estimated Manpower for Contract: 30.12

Manpower																	
	b Planned	0	0.88	0.88	0.88	3.43	3.43	3.43	3.43	3.43	3.43	3.43	3.44	0	0	0	0
	c Actual	0	0.88	0.88	0.88	3.43	3.43	3.43	2.36	2.36	2.36	2.36	2.36	2.36			
	d Variance	0	0	0	0	0	0	0	1.07	1.07	1.07	1.07	1.08	0			

11 Major Milestone Status



12 Remarks

13 Contractor Manager and Date

for Ben T. Zinn, Principal Investigator 7/7/80

14 Signature of Government Technical Representative and Date

E-16-646

GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA GEORGIA 30332

SCHOOL OF
AEROSPACE ENGINEERING

404 894-3000

DANIEL GUGGENHEIM SCHOOL
OF AERONAUTICS

August 5, 1980

Dr. Ernest Blase
Department of Energy
Washington, D.C. 20585

Subject: Progress report for the period July 1 through July 31, 1980 for work conducted under Contract DE-A505-79 ER 10068

During this reporting period tests were performed to establish procedures for obtaining quasi-steady test conditions for the combustion system. Various combinations of initial combustor loadings and coal feed rates on an interrupted basis were investigated. The temperatures of the exhaust gases, the combustor walls and the surrounding air space were monitored during testing to determine the changes in the heat release of the combustion process. In addition, the weight of the contents in the combustor basket was monitored and estimates were made on the composition of the contents of the combustion bed with respect to the relative volumes of burning coal, glowing coals, and ash.

The results of these initial tests indicate that in order for the heat release of the combustibles to be maintained constant both the coal feed rate and the composition of the combustion bed must vary with time. Alternate test procedures are currently being studied to obtain quasi-steady conditions in the system.

Work continued during this period on the development of an isokinetic probe; however, because of the inherent difficulties associated with the development of an isokinetic probe the existing probe and sampling train has been modified to be more compatible with the requirements of the experiment and analyzing equipment.

A continuous coal feed mechanism has been installed and tests are in progress to determine the effects of the intrusion of the feed pipe mechanism on the pulsations in the combustor. Subsequent testing will be initiated to determine if quasi-steady conditions can be established when the coal is fed to the combustor basket on a continuous basis.

Sincerely,

for Ben T. Zinn
Principal Investigator

BTZ/jj

FORM EIA-5
(21-79)

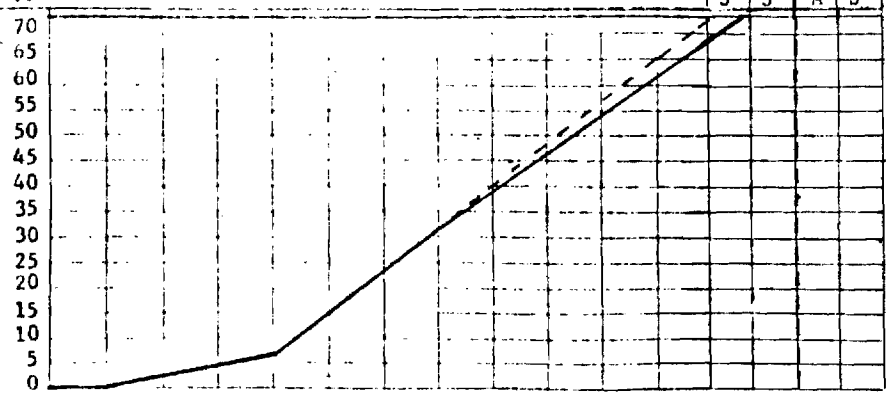
U.S. DEPARTMENT OF ENERGY

CONTRACT MANAGEMENT SUMMARY REPORT (REVISED 7/5/80)

1 Contract Identification: Development of a Coal Burning Pulsating Combustor for Power Generation	2 Reporting Period	3 Contract Number: DE-AS05-79ER10068
4 Contractor (name and address): Georgia Tech Research Institute, Administration Building, Georgia Institute of Technology, Atlanta, Georgia 30332		5 Contract Start Date: 1 June 1979 6 Contract Completion Date: 31 May 1980

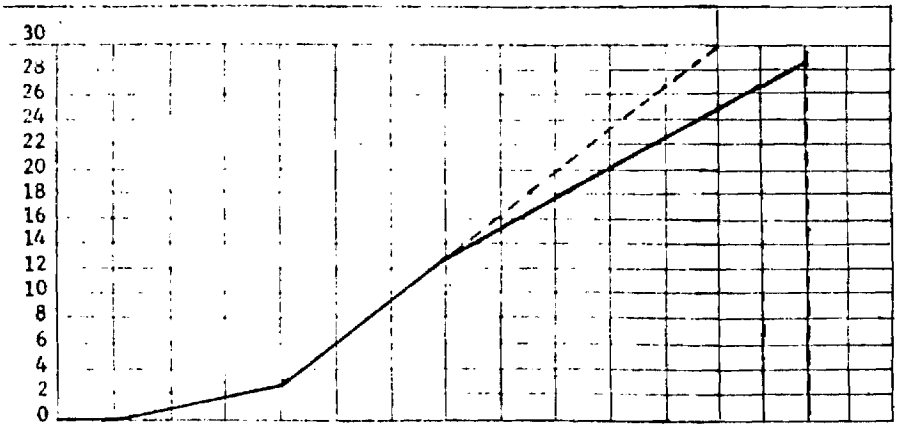
7 Months: J J A S O N D J F M A M | 8 FY 79-80 | EXTENSION J J A S

9 Cost Status



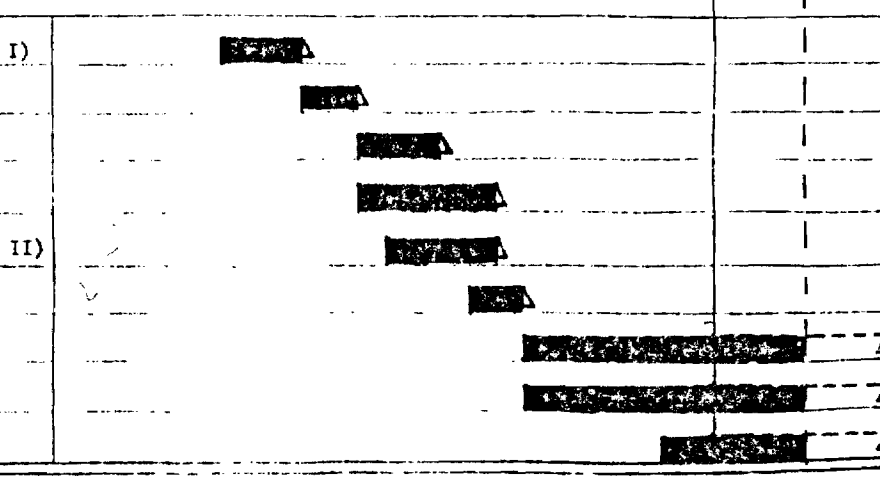
Accrued Costs																	
b Planned	0	2.15	2.15	2.15	8.37	8.37	8.37	8.37	8.37	8.37	8.37	8.40	0	0	0	0
c Actual	0	2.15	2.15	2.15	8.37	8.37	8.37	7.50	7.50	7.50	7.50	7.50	4.38	0		
d Variance	0	0	0	0	0	0	0	.87	.87	.87	.87	.90	0	0		

10 Manpower Status



Manpower																	
b Planned	0	0.88	0.88	0.88	3.43	3.43	3.43	3.43	3.43	3.43	3.43	3.44	0	0	0	0
c Actual	0	0.88	0.88	0.88	3.43	3.43	3.43	2.36	2.36	2.36	2.36	2.36	2.36	2.36		
d Variance	0	0	0	0	0	0	0	1.07	1.07	1.07	1.07	1.08	0	0		

11 Major Milestone Status



12 Remarks

13 Signature of Contractor's Project Manager and Date: [illegible] Rator 8/5/80

14 Signature of Government Technical Representative and Date

E-16-646

GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332

SCHOOL OF
AEROSPACE ENGINEERING

404-894-3000

DANIEL GUGGENHEIM SCHOOL
OF AERONAUTICS

September 8, 1980

Dr. Ernest Blase
Department of Energy
Washington, D.C. 20585

Subject: Progress report for the period August 1 through August 31, 1980 for work conducted under Contract DE-A505-79-ER 10068.

A portion of the efforts expended during August 1980 was concerned with the modification of the experimental setup and test procedure for the purpose of reducing the fluctuations in the measured temperature data. The latter are believed to be due to the nonuniform distribution of coal in the burning bed. The implemented modifications included a redesign of the feed system, a redesign of the basket holding the burning coal and changes in test procedure. The modified basket allows for a better flow of air through the coal bed and for the removal of the ash through its bottom. The modified feed system allows for the continuous feeding of coal into the bed and the modified test procedure involves the rotation of the coal bed during the test to allow for a more uniform distribution of the coal in the burning bed.

Since the developed coal burning Rijke-type combustor is self aspirating, tests were conducted to determine the effective air/fuel ratio in the combustor. The amount of coal fed into the bed was measured by the mass measurement system and the amount of air supplied to the bed was determined from velocity and temperature measurements at the entrance to the combustor tube. A thermocouple was used to obtain the temperature data and a TSI hot film probe was used to measure the velocity. Preliminary analysis of the data indicating that the air/fuel ratio is approximately nine when operating under pulsating conditions and it approximately equals four when operating under nonpulsating conditions. In this connection it should be pointed out that the velocity measurements indicated that the velocity remains fairly constant across the cross section of the tube, going rapidly to zero when the walls are approached.

Temperatures at different locations within the combustor were also measured during the reporting period. The locations of the various thermocouples is described in Fig. 1 and the corresponding temperature data are presented in Fig. 2. The shown temperatures were measured under pulsating and nonpulsating conditions and an examination of Fig. 2 indicates that the temperatures measured under pulsating conditions were always higher than the corresponding temperature measured under nonpulsating

conditions. The fluctuations in the measured data are believed to be due to the nonuniform burning in the bed and the periodic rotation of the bed during a test.

Tests were also conducted to determine the CO concentrations in the exhaust products under pulsating and nonpulsating conditions. The measured amounts of CO were negligible (less than 200 ppm) in both cases indicating incomplete combustion of carbon does not have to be considered in efficiency calculations. Furthermore, the CO concentrations were cooler in the pulsating combustion case. The CO measurement will have to be repeated with a more accurate instrument as doubts exist regarding the accuracy of the available instrument.

The fabrication of a water jacket for heating water in the Rijke-type combustor was also completed during the report period. This jacket was installed in the 3L/4 position and its effectiveness as a water heater will be tested shortly.

During the next report period, tests will be conducted to check the repeatability of the data presented in this report. Furthermore, efforts to eliminate the fluctuations in the measured data will continue. Finally, considerations will be given to the determination of the combustion efficiencies and heat losses through the combustor's walls.

Sincerely,

Ben T. Zinn
Principal Investigator

BTZ/jj

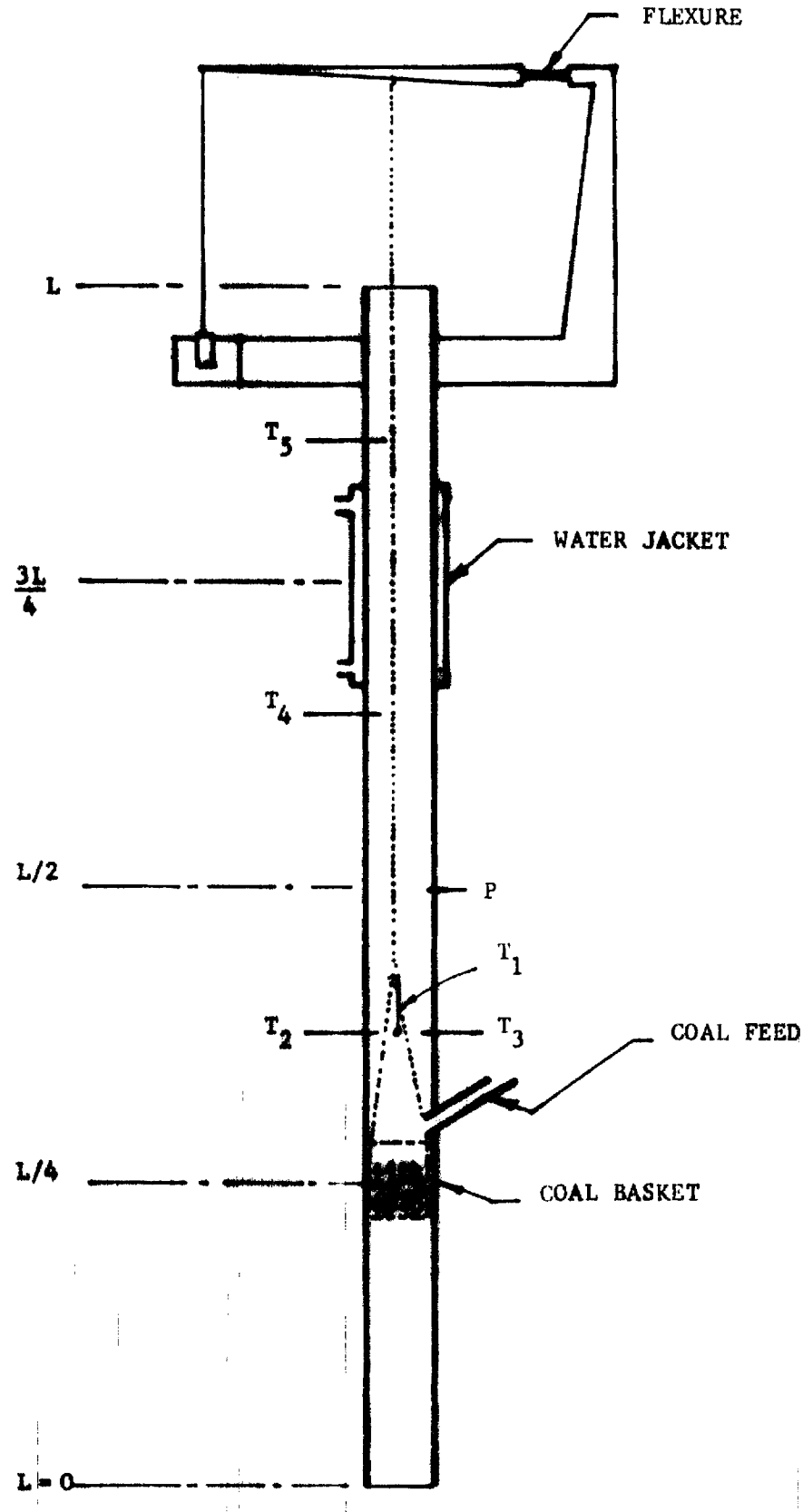


FIGURE 1. SCHEMATIC OF RIJKE TUBE PULSATING COMBUSTOR

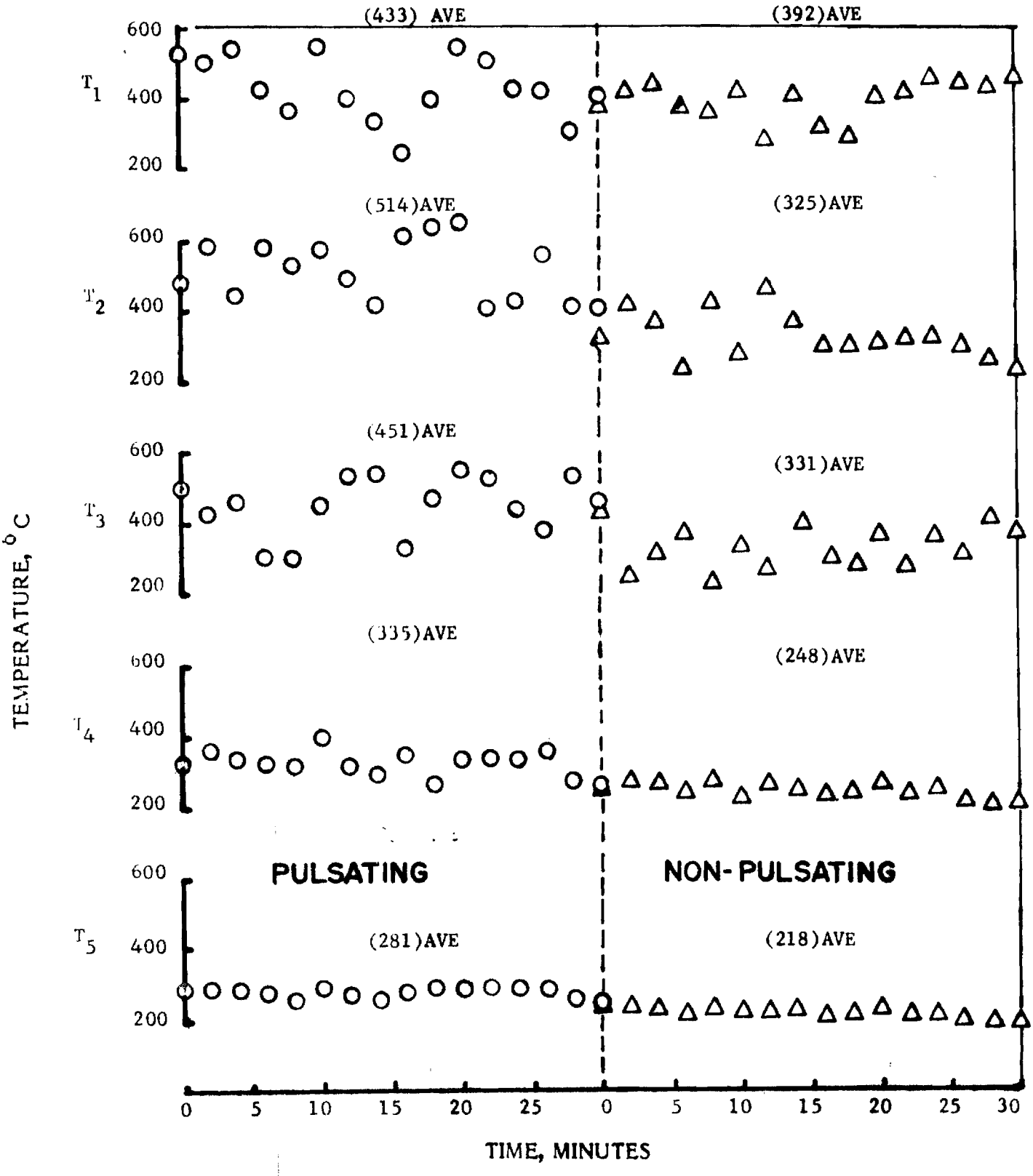


FIGURE 2. TEMPERATURE DATA MEASURED UNDER PULSATING AND NON-PULSATING CONDITION

FORM ERDA 52
(7/1/77)

U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

CONTRACT MANAGEMENT SUMMARY REPORT (REVISED 7/15/80)

1. Contract Identification	2. Reporting Period	3. Contract Number
Development of a Coal Burning Pulsating Combustor for Power Generation		DE-AS05-79ER10068

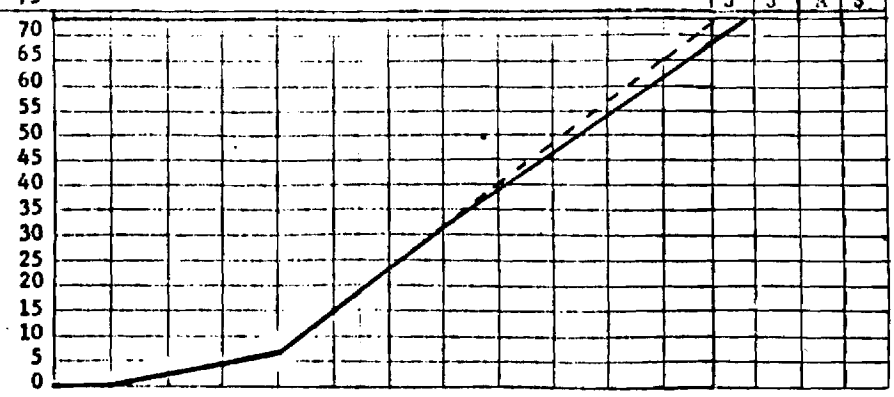
4. Contractor (name and address)	5. Contract Start Date	6. Contract Completion Date
Georgia Tech Research Institute Administration Building Georgia Institute of Technology Atlanta, Georgia 30332	1 June 1979	31 May 1980

7. Months	J	J	A	S	O	N	D	J	F	M	A	M	8. FY 79-80 EXTENSION J	J	A	S

9. Cost Status

a. DOLLARS (THOUSANDS)

b. Total Contract Value: 73.44

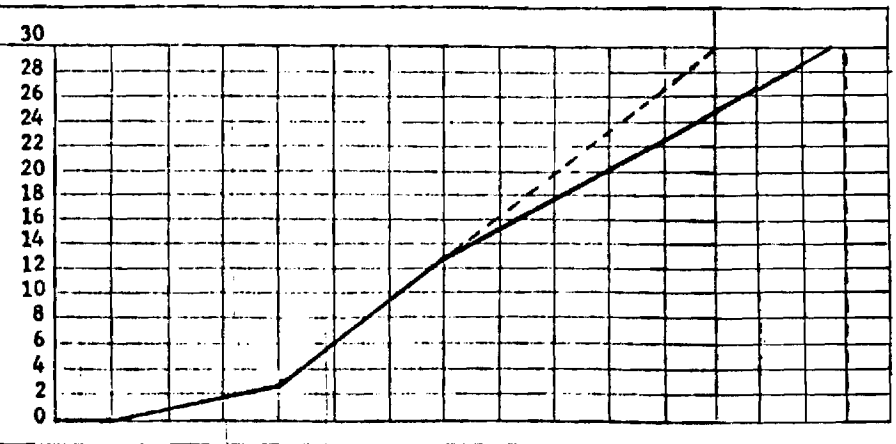


Accrued Costs																
	b. Planned	0	2.15	2.15	2.15	8.37	8.37	8.37	8.37	8.37	8.37	8.37	8.40	0	0	0	0
	c. Actual	0	2.15	2.15	2.15	8.37	8.37	8.37	7.50	7.50	7.50	7.50	7.50	4.38	0	0	
	d. Variance	0	0	0	0	0	0	0	.87	.87	.87	.87	.90	0	0	0	

10. Manpower Status

a. MANHOURS (HUNDREDS)

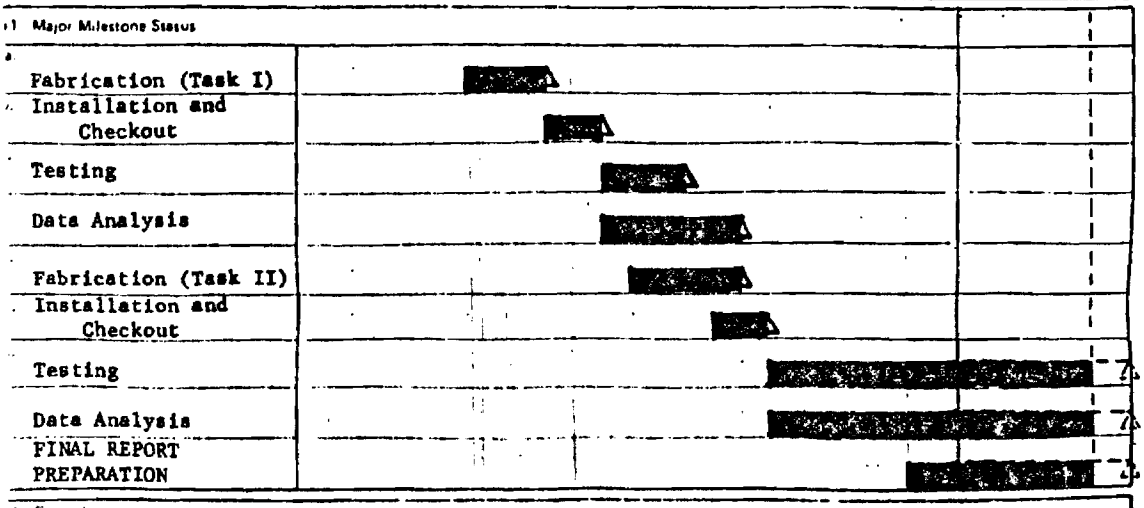
b. Total Estimated Manpower for Contract: 30.12



Manpower																	
	b. Planned	0	0.88	0.88	0.88	3.43	3.43	3.43	3.43	3.43	3.43	3.43	3.44	0	0	0	0
	c. Actual	0	0.88	0.88	0.88	3.43	3.43	3.43	2.36	2.36	2.36	2.36	2.36	2.36	2.36	0.67	
	d. Variance	0	0	0	0	0	0	0	1.07	1.07	1.07	1.07	1.08	0	0	0	

11. Major Milestone Status

a.



12. Remarks

Ben T. Zinn, Principal Investigator 9/8/80

13. Signature of Contractor's Project Manager and Date	14. Signature of Government Technical Representative and Date
Ben [illegible]	

GEORGIA INSTITUTE OF TECHNOLOGY
SCHOOL OF AEROSPACE ENGINEERING
ATLANTA, GEORGIA 30332
Telephone 404-894-3033/3000
Telex: SY2507 GTRI OCA ATL

Ben T. Zinn
Regents Professor
Daniel Guggenheim
School of Aeronautics

October 6, 1980

Dr. Ernest Blase
Department of Energy
Washington, D.C. 20585

Subject: Progress report for the period September 1 through September 30, 1980 for work conducted under contract DE-A505-79-ER 10068

The efforts conducted during this period investigated the effect of coal bed design (i.e., the design of the basket that holds the burning coal) upon the coal burn rate and the stability of the flow conditions inside the combustor. In addition, efforts conducted during this period were concerned with the investigation of the effect that the recirculating of unburned coal, that drops underneath the coal bed, through the bed has upon the combustor performance.

In one series of tests, a circular, funnel-like collection of wires that directed the fed coal into the center of the bed was attached to the top of the basket supporting the coal bed. While this modification reduced the previously observed temperature fluctuations within the combustor, the latter were not completely eliminated. Considering the physics of the problem, it is believed that a major cause of the observed temperature fluctuations is the heterogeneity of the coal particles that are being fed into the combustion bed. In this connection it should be pointed out that the observed temperature fluctuations should not have an adverse effect upon the performance of the developed combustor.

The modified coal bed design had resulted in a drastic increase (i.e., twice as high as before) in the coal burn rate. The measured coal burn rate in the Rijke tube combustor were also higher than those measured in fluidized bed combustors that represent the current state of art in coal combustion. Incidentally, these burn rate comparisons were done on the basis of burn rate per unit area of the combustor bed in order to account for combustor size differences.

The metal wire basket carrying the coal bed has holes in its bottom that allow for the flow of oxidizing air through the burning coal bed. The presence of these holes in the bottom of the basket also results in small particles of coal, coal char and ash falling through these holes to the outside through the bottom of the tube. In order to improve the combustion efficiency, the falling particles were collected and recirculated through the bed. The recirculated coal was mixed with fresh coal in the ratio of one to three. Investigating the effect of this recirculation showed that it resulted in about a fifteen percent reduction of the newly achieved burn rate and a considerable improvement in the combustion efficiency. In this connectio it needs to be pointed out that even the reduced burn rate achieved with coal recirculation was higher than the burn rates reported for many fluidized bed combustors.

During the next reporting period, efforts will continue to determine combustion efficiencies of the system. Finally, part of the time will be use to solve problems concerned with the reliance of the temperature data measured with thermocouples.

Sincerely,

Ben T. Zinn
Principal Investigator

BTZ/jj

ALERM ERDA 52
(2-1-77)

U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

CONTRACT MANAGEMENT SUMMARY REPORT (REVISED 7/5/80)

1 Contract Identification	2 Reporting Period	3 Contract Number
Development of a Coal Burning Pulsating Combustor for Power Generation		DE-AS05-79ER10068

4 Contractor (name and address)	5 Contract Start Date	6 Contract Completion Date
Georgia Tech Research Institute Administration Building Georgia Institute of Technology Atlanta, Georgia 30332	1 June 1979	31 May 1980

7 Months	J	J	A	S	O	N	D	J	F	M	A	M	8 FY 79-80 EXTENSION J	J	A	S

9 Cost Status

a DOLLARS (THOUSANDS)

b Total Contract Value: 73.44

Accrued Costs																	
b Planned	0	2.15	2.15	2.15	8.37	8.37	8.37	8.37	8.37	8.37	8.37	8.40	0	0	0	0
c Actual	0	2.15	2.15	2.15	8.37	8.37	8.37	7.50	7.50	7.50	7.50	7.50	4.38	0	0	0
d Variance	0	0	0	0	0	0	0	.87	.87	.87	.87	.90	0	0	0	0

10 Manpower Status

e MANHOURS (HUNDREDS)

g Total Estimated Manpower for Contract: 30.12

Manpower																	
b Planned	0	0.88	0.88	0.88	3.43	3.43	3.43	3.43	3.43	3.43	3.43	3.44	0	0	0	0
c Actual	0	0.88	0.88	0.88	3.43	3.43	3.43	2.36	2.36	2.36	2.36	2.36	2.36	2.36	0.67	0
d Variance	0	0	0	0	0	0	0	1.07	1.07	1.07	1.07	1.08	0	0	0	0

11 Major Milestone Status

a Fabrication (Task I)
b. Installation and Checkout
c. Testing
d Data Analysis
e Fabrication (Task II)
f Installation and Checkout
g Testing
h Data Analysis
FINAL REPORT PREPARATION

12 Remarks

13 Signature of Contractor's Project Manager and Date

Bet... ...ecipato... 10/6/80

14 Signature of Government Technical Representative and Date